A Behavioral Approach to Improving Pedestrian Infrastructure at Signalized Intersections

Amy Wyman[1], Helena Breuer, David S. Hurwitz

School of Civil and Construction Engineering, Oregon State University, 1491 SW Campus Way, Corvallis, OR 97331, wymana@oregonstate.edu
School of Civil and Construction Engineering, Oregon State University, 1491 SW Campus Way, Corvallis, OR 97331, breuerh@oregonstate.edu
School of Civil and Construction Engineering, Oregon State University, 1491 SW Campus Way, Corvallis, OR 97331, david.hurwitz@oregonstate.edu

Abstract

Washington County, Oregon, United States, maintains multiple perpendicular pedestrian crossings at signalized intersections served by two pushbuttons located on a single pushbutton pole. County engineers have observed that pedestrians frequently push both pushbuttons, regardless of the crosswalk they intend to use. This behavior incurs unnecessary delay for all intersection users—particularly at locations operating split phases and where the pedestrian phase controls the time allocated to the concurrent vehicular phase. To address this challenge, the exploratory study presented herein investigates how pedestrians search for information at a signalized intersection via a field experiment in which participants crossed an intersection wearing a mobile eye tracker. Usable eye tracking data for seven participants was collected. The data suggests that participants understood how to associate pushbuttons with corresponding crosswalks and used pedestrian infrastructure at the study location to do so. However, additional information could help participants identify which crosswalks are next to be served and make more efficient crossing decisions. Eye tracking data suggests that participants began observing vehicle traffic earlier and more consistently than other infrastructure elements on their approach to the pushbutton pole. Pushbuttons and pushbutton signage were the last infrastructure elements observed, with most observations occurring less than three seconds to button push. Of traffic signals and traffic, pushbuttons and pushbutton signage, and pedestrian signals, participants fixated on traffic signals and traffic approximately 45% of the time and on pushbuttons and pushbutton signage approximately 51% of the time.

Keywords: Pedestrians; intersection operations; pedestrian pushbuttons; crosswalks; signalized intersections; human factors

[1] * Corresponding author. Tel.: +001-971-219-7837;
E-mail address: wymana@oregonstate.edu

1. Introduction

Despite advances in automated pedestrian detection, pedestrian pushbuttons are the primary means by which a pedestrian can request a WALK signal at a signalized intersection in the US—and will likely remain so for some time (*1*, *2*). Multiple signalized intersection corners in Washington County, Oregon, United States (US), have two pushbuttons for perpendicular pedestrian crossings at signalized intersections located on a single pushbutton pole. County engineers have observed that pedestrians frequently push both pushbuttons on the pole, regardless of the crosswalk they intend to use. When the pedestrian phase for the unintended crosswalk activates, it incurs unnecessary delay for all intersection users—particularly at locations where the pedestrian phase controls the time allocated to the concurrent vehicular phase. Delay is exacerbated at intersections with split phasing and coordination, where pedestrian actuations can throw the corridor out of coordination (*3*, *4*). The study presented herein investigates how pedestrians search for and use information presented at the intersection through a field experiment in which participants performed several intersection crossings wearing a mobile eye tracker. The study addresses the following research questions:

1. Is there a demonstrated need for modifications to existing pedestrian infrastructure at the study intersection that would help pedestrians correctly associate which pushbutton corresponds to which crosswalk and which crosswalk will be served next?
2. Where do pedestrians look for information when choosing between two acceptable crossings?
3. When do pedestrians look for information from specific roadway elements on their approach to the pushbutton pole?

The results of this exploratory study were intended to inform a second study, which involves the development and survey assessment of conceptual design alternatives representing modifications to signals or signage. This paper presents the results of the first study.

2. Methodology

This exploratory study was conducted at the intersection of SW Scholls Ferry Road and SW Nimbus Avenue in Washington County, Oregon (Figure 1a). Pushbuttons for both crosswalks at each intersection corner are located on a single pole, with signage explaining which pushbutton corresponds to which crosswalk (Figure 1b). The intersection's north and south approaches operate sequentially with split phasing. Depending on time of day, the intersection's east and west approaches operate with a combination of split phasing, concurrent protected east and west left turns, and concurrent east and west through movements with and without permissive flashing left-turn yellow arrows. To receive the WALK indication in the same signal cycle that a pushbutton is activated, the pedestrian must activate the pushbutton prior to the onset of the concurrent vehicular phase.

Figure 1a: Aerial image of SW Scholls Ferry Road and SW Nimbus Avenue, Washington County, Oregon, US; Figure 1b: Pushbuttons and pushbutton signage at study location.

Participants were recruited within Washington County by Washington County staff and from neighboring communities via email announcement. Participants were outfitted with Mobile Eye-XG (Applied Science Laboratories) eye tracking glasses and asked to travel across the intersection twice, completing two "there-and-back" tours. On one tour, the participant travelled to a corner of the intersection that required crossing only one approach of the intersection. On the second tour, the participant travelled to the diagonal corner of the intersection, requiring them to cross two approaches of the intersection. Each participant experienced six scenarios which required them to select a crossing: three scenarios where only one crosswalk would lead to their desired destination, and three “choice” scenarios where either crosswalk would lead to their destination. A “reasonably efficient” crosswalk choice was a choice consistent with the expectation that the next crosswalk to be served will be the one associated with the vehicular phase which is not currently active; an “inefficient” crosswalk choice occurred when the participant selected the crosswalk for which the concurrent vehicular phase appeared to already be active, consistent with common signal timing practices in Washington County at the time. High quality eye tracking data was collected to determine how much time participants spent looking at AOIs and when they looked at AOIs, consistent with established methods used in similar eye-tracking experiments (e.g., *5*). Eye tracking data was recorded from the time the participant set foot on the intersection corner to the time they made their final button push on that corner. The following AOIs for both north-south and east-west approaches were considered: pedestrian signal heads, pushbutton signage, pushbuttons, vehicle traffic signals, and vehicle traffic. Elements that a participant looked at for more than 0.10 seconds constituted fixations, a surrogate measure of visual attention. Time to button push, the time elapsed between when a participant made a fixation on an element and when they pushed the pushbutton, was calculated by subtracting the duration of each eye tracking segment from the fixation start time. The experiment was approved by the OSU IRB Office (Study No. IRB-2020-0511).

3. Analysis and Results

3.1 Post-Task Survey

Nine total participants completed post-task surveys after the field experiment. Seven participants identified as male and two identified as female. There were three participants each in the following age ranges: 25 to 34, 45 to 54, and 55 to 64. In the post-task survey, when presented a hypothetical crossing scenario in which the participant was given a destination intersection corner that required them to only cross one intersection leg, as shown in Figure 2a, three of nine participants answered that they would either “Always” or “About half the time” push both pushbuttons on the signal pole to initiate a crossing. When asked to explain, one participant who answered “About half the time” remarked that they would push the pushbuttons “without looking at which direction they were for”. When presented with a hypothetical crossing scenario requiring the participant to cross to the diagonal corner of the intersection using two crosswalks, Figure 2b, six of nine participants indicated that they would push both pushbuttons and cross at whichever crosswalk let them cross first “About half the time” or “Most of the time”. Three participants responded that they would “Rarely” check which crosswalk would be first to serve them; the remaining participants answered that they would check “Most of the time” or “About half the time”.

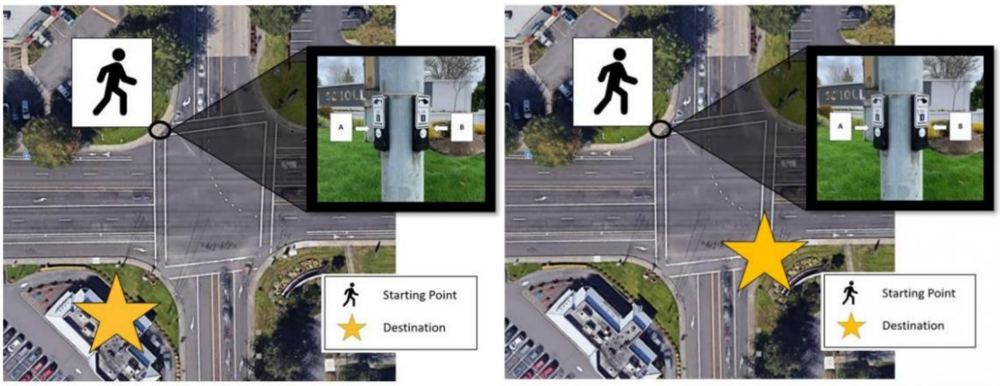

Figure 2a: Adjacent crossing survey graphic; Figure 2b: Diagonal crossing survey graphic.

3.2 Field Experiment

Seven of the nine participants who completed the pre- and post-task surveys had usable eye tracking data. Two of these participants pushed both pushbuttons during a choice scenario at an intersection corner. The participants pushed one pushbutton, waited several seconds, remarked that they should have pushed the pushbutton for the other crosswalk because it would be served first, then pushed the second pushbutton. Each participant made a reasonably efficient button push based on common signal timing practices in Washington County. One of these two participants, Participant A, received the WALK indication for the crosswalk corresponding to their second button push first and crossed on this indication, per their expectation. Participant B received the WALK indication corresponding to their first button push first, yet stopped paying attention to it after remarking that the other crosswalk would turn first, and did not notice the pedestrian signal had changed until mid-way through the flashing DONT WALK countdown. Participant B did not try to cross during the remaining countdown; they waited and crossed with the indication corresponding to their second button push.

Across seven participants, there were 19 choice scenarios with usable eye tracking data in which participants could make a reasonably efficient crossing decision; 15 of these scenarios (79%) were reasonably efficient. Fixations on traffic and traffic signals accounted for 14% of fixation time on AOIs for participants who made an inefficient crosswalk choice on their first button push. Fixations on traffic and traffic signals accounted for 56% of fixation time on AOIs for participants who made a reasonably efficient crosswalk choice on their first button push. While conclusions are limited by sample size, these results suggest that participants used traffic and traffic signals to choose reasonably efficient crosswalks. Table 1 summarizes the total time spent fixating on each AOI analyzed prior to making a first east-west or north-south button push. When data from all approaches is combined, participants spent the most time fixating on vehicle traffic (42%), followed by pedestrian pushbuttons (33%), pushbutton signage (17%), pedestrian signals (4%), and traffic signals (3%).

Table 1: Fixations by First Button Push for Crosswalk Choice Scenarios

	East-West Button Push		North-South Button Push	
AOI	**Fixation Duration (s)**	**% of Total Fixation Time on AOIs**	**Fixation Duration (s)**	**% of Total Fixation Time on AOIs**
East-West Pushbutton	2.47	27%	0.13	1%
East-West Pedestrian Signal	0.33	4%	0.00	0%
East-West Pushbutton Signage	0.67	7%	0.10	1%
East-West Traffic	3.07	34%	1.95	21%
East-West Traffic Signal	0.43	5%	0.13	1%
North-South Pushbutton	0.60	7%	2.82	31%
North-South Pedestrian Signal	0.00	0%	0.46	5%
North-South Pushbutton Signage	0.44	5%	1.94	21%
North-South Traffic	1.02	11%	1.55	17%
North-South Traffic Signal	0.00	0%	0.00	0%

The order in which participants looked at AOIs was also considered. Figure 3 summarizes the percent of total time spent looking at each AOI category based on time to button push, where t=0 seconds represents the time at which the participant made their first button push. Vehicle traffic was the most consistently attended to AOI for the duration of the participants' approaches to the pushbutton until approximately 3 seconds to button push, when fixations on pushbuttons and pushbutton signage rose dramatically.

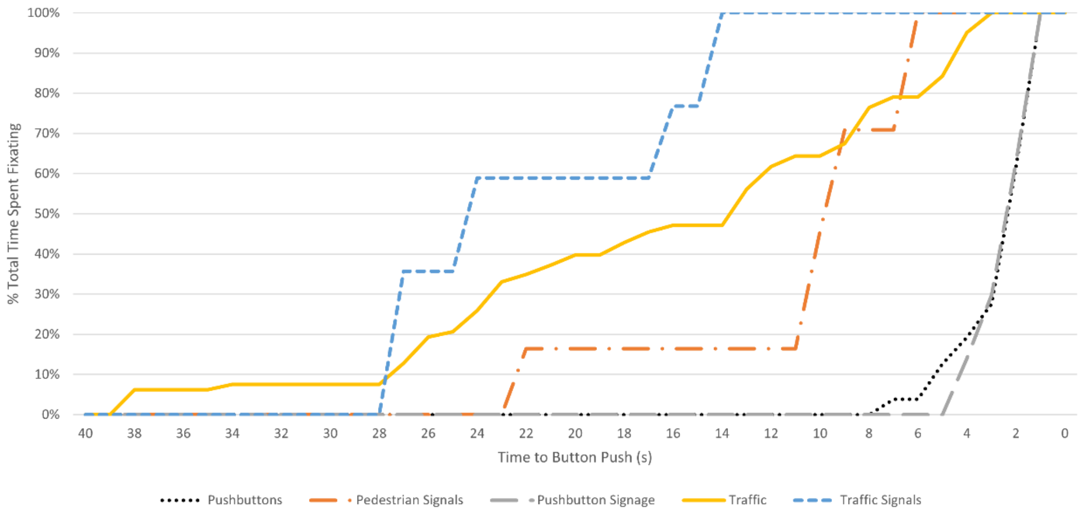

Figure 3: Time fixating on AOIs prior to first button push.

4. Discussion

During the field experiment, participants fixated more on pushbuttons and pushbutton signage than many other AOIs. Combined, fixations on pushbuttons and pushbutton signage accounted for approximately 51% of total time spent fixating on AOIs, suggesting that study participants used pushbutton markings and signage to identify which crosswalk corresponded to which pushbutton during the field experiment. Participants appeared to begin observing vehicle traffic earliest on their approach to the pushbutton pole, almost as soon as beginning their approach. Observing which vehicles are moving on which approach can provide similar information to that of a traffic signal, as it implies the active vehicular phase. The relatively large amount of time participants spent fixating on vehicle traffic is consistent with similar eye-tracking studies, like Egan (2012) and Geruschat et al. (2003), who observed that vehicles were among the most fixated-on category of AOIs they examined among adult participants (6, 7). Additionally, participants who made inefficient crosswalk choices made fewer fixations on traffic and traffic signals than participants who made reasonably efficient crosswalk choices, suggesting that participants used traffic and traffic signals to determine which pushbutton to select. These observations, combined with Participant B's experience, suggest that pedestrians actively search for information about which crosswalk is next to be served and could benefit from relevant extra information, particularly at signalized intersections with split- or time-variable phasing. In future work, the authors will use these results to explore potential modifications to existing pedestrian infrastructure at the study location which communicate which crosswalk will be served next. Conceptual alternatives will be developed and assessed via a large-scale survey study of persons in Washington County, Oregon and the US. Because participants spent a significant amount of time looking at pushbuttons and pushbutton signage just prior to making their pushbutton selection, conceptual alternatives which modify pushbuttons and pushbutton signage will primarily be considered.

5. Conclusions

The results of this exploratory study suggest additional information could help pedestrians identify which crosswalks are next to be served. Eye tracking data suggests that participants observed vehicle traffic signals and traffic on both the east-west and north-south approaches to choose which pushbutton to push, often earlier than other infrastructure elements on their approach to the pushbutton pole. Pushbuttons and pushbutton signage were last to be observed, with most fixations occurring less than three seconds to button push. Traffic and traffic signals comprised approximately 45% of total fixations for crosswalk choice scenarios, while fixations on pedestrian pushbuttons and pushbutton signage comprised approximately 51% of total fixations for crosswalk choice scenarios.

Acknowledgment

This material is based upon work supported by Washington County under Contract No. 19-1336. The authors wish to thank the following engineers at Washington County for their support of this research and assistance with field technology set-up and recruiting: Shaun Quayle, P.E, Stacy Shetler, P.E., and Matt Dorado. We would also like to thank our undergraduate research assistant, Benjermin Ochsner, for his help reducing eye tracking data.

References

1. Bradbury, K., J. Stevens, L. N. Boyle, and S. Rutherford, To Go or Not to Go: Pedestrian Behavior at Intersections with Standard Pedestrian Call Buttons, Transportation Research Record: Journal of the Transportation Research Board, 2012. 2299: p. 174–179. https://doi.org/10.3141/2299-19.
2. Larson, T., A. Wyman, D. S. Hurwitz, M. Dorado, S. Quayle, and S. Shetler, Evaluation of Dynamic Passive Pedestrian Detection. Transportation Research Interdisciplinary Perspectives, 2020. 8: n.p. https://doi.org/10.1016/j.trip.2020.100268.1
3. Tian, Z. Z., T. Urbanik, K. K. Kaci, M. A. Vandehey, and H. Long, Pedestrian Timing Treatment for Coordinated Signal Systems. Traffic and Transportation Studies, 2000. p. 533–540. https://doi.org/10.1061/40503(277)83.
4. Chowdhury, S. and A. Stevanovic, Estimating Pedestrian Impact on Coordination of Urban Corridors. Transportation Research Record: Journal of the Transportation Research Board, 2019. 2673: p. 265–280. https://doi.org/10.1177/0361198119844971.
5. Jashami, H., D. S. Hurwitz, C. Monsere, and S. Kothuri, Evaluation of Driver Comprehension and Visual Attention of the Flashing Yellow Arrow Display for Permissive Right Turns. Transportation Research Record: Journal of the Transportation Research Board, 2019. 2673: p. 397–407. https://doi.org/10.1177/0361198119843093.
6. Egan, C. D., Children's Gaze Behaviour at Real-World and Simulated Road Crossings. 2012. https://www.napier.ac.uk/~/media/worktribe/output-189868/eganthesisfinalpdf.pdf
7. Geruschat, D. R., S. E. Hassan, and K. A. Turano, Gaze Behavior While Crossing Complex Intersections. Optometry and Vision Science, 2003. 80: p. 515–528. https://doi.org/10.1097/00006324-200307000-00013.