PERMISSIVE LEFT-TURN BEHAVIOR AT THE FLASHING YELLOW ARROW IN THE PRESENCE OF PEDESTRIANS

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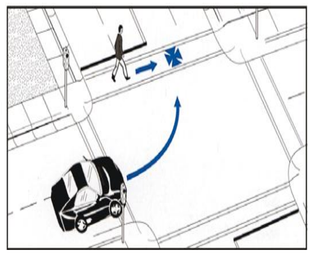
1.0 INTRODUCTION

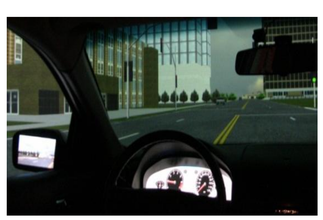
Protected left-turns can improve intersection safety, but they prohibit vehicles from utilizing potentially acceptable gaps in oncoming traffic and thus reduce efficiency. Protected/permissive left-turn (PPLT) phasing has become popular at intersections as a way to balance safety and efficiency. A driver facing a PPLT traffic signal indication must yield the right-of-way to opposing traffic (vehicles and bicycles) and conflicting pedestrians in the crosswalk. In this situation the driver workload is relatively high and drivers can fail to scan for pedestrians while performing permissive left-turns. This is particularly an issue in settings where driver expectation of pedestrians is low.



Past research has demonstrated the flashing yellow arrow (FYA) as the preferred signal indication for protected/permissive left-turn (PPLT) based on driver comprehension, and the MUTCD now includes guidelines for FYA operation. Washington County, Oregon replaced many intersections that had protected left turn operations with FYA PPLT operation. Due to public comments of increased pedestrian discomfort in the crosswalk, operation of the FYA was halted at several intersections. This provided the research motivation and context to study the interaction between pedestrians and drivers making permissive left-turn maneuvers.

2.0 METHODOLOGY

This research project utilized the Oregon State University (OSU) driving simulator to model characteristics from candidate FYA locations identified from historical crash data. 27 subject drivers performed to 24 independent left-turns with varying physical intersection characteristics such as signal head configurations, opposing vehicular volume, and pedestrian traffic during a single 45 minute experimental trial. Data was collected using head mounted eye tracking equipment.



Driving Simulator

The OSU driving simulator is a high-fidelity moving base simulator with a full 2009 Ford Fusion mounted on top of a high performance electric pitch motion system.

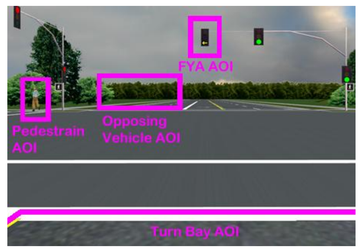
2.0 METHODOLOGY CONTINUED

Eye Tracker

Eye tracking data was collected using the Mobile Eye-XG platform from Applied Science Laboratories, with a sampling rate of 30 Hz with an accuracy of 0.5˚ to 1˚

Areas of Interest

Areas of interest (AOI) were defined using the eye tracking software. Fixations of longer than 0.10 second were recorded, tabulated, and averaged. AOIs included **Pedestrians**, the **FYA Signal**, **Opposing Vehicles**, and the **Turn Bay**.

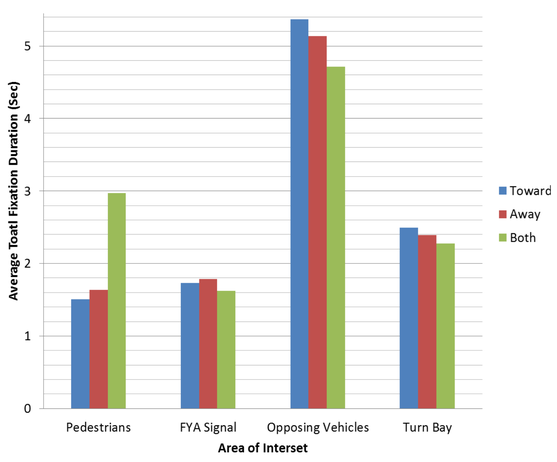


a b c

The data was separated by pedestrian movement cases; one pedestrian walking **toward** the driver (a), two pedestrians walking from **both** directions (b), one pedestrian walking **away** from the driver (c), and no pedestrians (**none**; not pictured). Then, average total fixation durations (ATFD) were calculated for each AOI.

3.0 ANALYSIS & RESULTS

ATFD durations were next compared between pedestrian movement cases using an ANOVA analysis and family-wise comparisons were made using the Tukey-Kramer Honest Significant Difference.



3.0 ANALYSIS & RESULTS CONTINUED

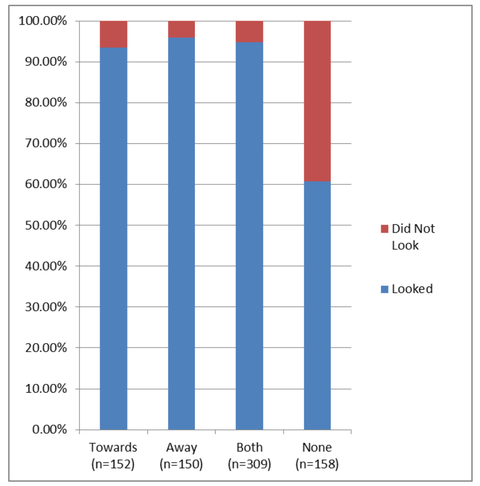
Family-wise Comparison of ATFD

Areas of Interest	Toward vs Away		Toward vs Both		Away vs Both	
	p-value	Sig	p-value	Sig	p-value	Sig
Pedestrians	0.489	No	< 0.001	Yes	< 0.001	Yes
FYA Signal	0.958	No	0.848	No	0.689	No
Opposing Veh	0.848	No	0.259	No	0.564	No
Turn Bay	0.877	No	0.533	No	0.831	No

Significant differences were observed between the **Toward vs Both** case and the **Away vs Both** case. No other comparisons were found to be significantly different. This shows that when four pedestrians are present in the conflicting crosswalk, the driver's ATFD on crossing pedestrians is greater than when there is minimal pedestrian activity.

Whether or not drivers fixated on pedestrians (or likely pedestrian locations if no pedestrians were present) was also considered.

It was observed that 4% to 7% of drivers did not fixate on pedestrians in the crosswalk when completing their left-turn. Additionally, 39% of drivers did not fixate on likely pedestrian locations when pedestrians were not present.



4.0 CONCLUSIONS

1) Drivers have longer average total fixation durations on pedestrians when multiple pedestrians are present.
1) When pedestrians are present, 4% to 7% of drivers do not fixate on pedestrians in the crosswalk while completing their left-turn.
2) When pedestrians are not present, 39% of drivers do not fixate on likely pedestrian locations while completing their left-turn.

5.0 ACKNOWLEDGEMENTS

This project was funded by the Oregon Transportation Research and Education Consortium (OTREC) a USDOT University Transportation Center with in-kind matching fund from Washington County, Oregon.