The Flashing Right Turn Signal with Pedestrian Indication: A Human Factors Study to Assess Driver Comprehension

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Abstract. Given the increased fatality risk of older pedestrians, and the large and growing older adult population in the United States and around the world, many countermeasures to ensure aging pedestrian safety have been explored (e.g., different types of crosswalk markings). The present study sought to investigate the potential of an experimental countermeasure, the flashing pedestrian indicator (FPI). This signal, intended for right-turning drivers, alternates between a yellow arrow and a pedestrian symbol when a pedestrian calls for a walk phase at a signalized intersection. The purpose of this signal is to cue right-turning drivers to the potential presence of a pedestrian, encourage scanning to the right for crossing pedestrians, and promote driver yielding behaviors. We conducted a study to gauge the comprehension of drivers who were naïve to the signal to explore if the FPI's intended message was understood. Participants were presented with scenarios depicting the FPI and other signal states and were asked the meaning of the observed signal (open-ended and multiple choice questions). Comprehension was tested across a range of age groups: younger (21–35 years), middle-aged (50–64), and older adult (65+) drivers. While in general the signal was understood, some participants were confused regarding the meaning of the FPI in certain situations. Potential positive effects of the FPI need to be weighed against potential confusion before any further recommendations can be made regarding the FPI as a potential countermeasure to assist with pedestrian crashes.

Keywords: Pedestrian safety · Transportation safety · Traffic signals · Older adults

1 Disclaimer

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation or the U. S. Department of Transportation.

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2 Introduction

Pedestrian Crash Risk. According to data from the National Highway Traffic Safety Administration (NHTSA), in 2012, pedestrians represented 14 % of all traffic fatalities in the United States, an increase from 11 % in 2003 [1]. Unfortunately, older pedestrians are at greater risk compared to their younger counterparts. Nationally, the fatality rate of individuals aged 75 to 84 was 2.70 fatalities per 100,000 in the population in 2012, compared to a rate of 1.51 across all age groups. Fatality rates were especially elevated for male pedestrians 85 years of age or older (4.02). Increased risk is likely due to greater fragility (a crash that might injure a younger pedestrian may kill an older pedestrian) and slower walking speeds that increase exposure risk [2, 3]. Additionally, fear of falling may cause older pedestrians to both move more slowly and to attend to the ground rather than traffic around them while crossing [4]. Attempts to protect pedestrians from crashes by alerting drivers to their potential presence, as a result, are likely to differentially benefit older pedestrians (in addition to making the roadway safer for pedestrians of all ages).

Why Do Pedestrian Crashes Occur? A fundamental aspect of visual processing is that we can fail to notice seemingly obvious objects and events (such as a pedestrian entering the roadway) if we are not actively looking for them. This likely contributes in part to pedestrian crashes. The classic example is the experiment Simons and Chabris conducted in which participants were asked to watch a video depicting two teams of basketball players, one wearing white and the other wearing black [5]. Participants were asked to count the number of times the players dressed in white passed the ball. During this short video, a gorilla walked through the group of players, pounded its chest, and walked away, being fully visible for 5 s of the 75-second-long video. Surprisingly, 50 % of participants failed to notice this unusual event despite it being easily observed by anyone asked to look for the gorilla. Of particular note is that instances of "inattentional blindness" have been observed in observers who directly fixated the unexpected event with their eyes, suggesting the problem in this particular case is often not one of looking (scanning), but seeing. Inattentional blindness has been proposed as a contributing cause in crashes and is consistent with numerous reports of drivers reporting not having seen pedestrians before a crash. If observers can fail to notice extremely salient and unusual events, they can also fail to notice pedestrians. By alerting drivers that they should expect pedestrians, these instances of inattentional blindness will likely be reduced. Scanning, however, may play an important independent role. A driver turning right may be biased to scan left for vehicles [6], and insufficient scanning to the right puts pedestrians crossing to the right at risk of being struck while crossing. Countermeasures that encourage scanning for pedestrians and the expectation that pedestrians may be present are likely to decrease instances in which drivers fail to yield to an unnoticed pedestrian.

A Proposed Solution. The Flashing Turn Signal Head with Pedestrian Indication (which we will abbreviate as Flashing Pedestrian Indicator, or FPI) has been one proposed solution to reduce pedestrian crashes at signalized intersections. The FPI alternates between a yellow arrow and pedestrian symbol (Fig. 1). Consider a right-turning driver. If the pedestrian button is pressed for the conflicting crosswalk (to the right), the Walk

pedestrian signal would activate, and instead of a green arrow (in cases of a dedicated right-turn lane) or in addition to a circular green (in cases of a shared through/right-turn lane) the driver would see the FPI. This signal has two potential benefits. First, it may increase the awareness of pedestrians crossing or planning to cross, and second, it might encourage scanning to the right for pedestrians in and around the roadway. Based on the attention literature, this type of flashing/onsetting signal is one of the best methods to attract attention to a message [e.g., 7], and arrows have been found to reflexively orient attention in the direction they point [e.g., 8–11]. Thus there is reason to believe that this new signal may be effective.

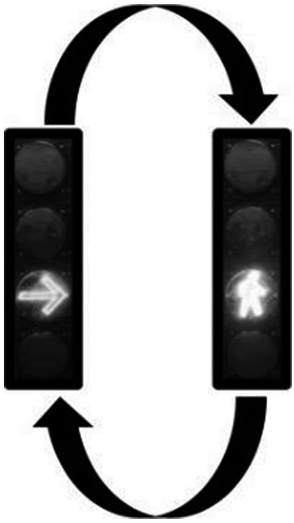

Fig. 1. The flashing turn signal head with pedestrian indication (FPI)

However, as with any new traffic control device, it is important to understand whether drivers of all ages comprehend the meaning it is intended to convey (right turns are permissible but a pedestrian may be present, yield if appropriate). If this message is not conveyed, at best the countermeasure may not have its intended effect, and at worst drivers may misinterpret it in such a way that pedestrian risk is increased. For example, in a previous studies, some participants interpreted a solid yellow arrow as meaning "hurry up and turn" before the signal turns red [12]. If the yellow arrow component of the proposed signal results in a rush to complete a turn, pedestrian risk might be increased rather than decreased. In the subsequently reported study younger, middle-aged, and older drivers' comprehension of the FPI was examined.

3 Method

This experiment presented participants who had never seen the FPI previously with the FPI and other signal states and asked them for the meaning of the presented signal.

Participants. We collected open-ended responses, and then multiple-choice responses, from a total of 15 younger (21 to 35 years, $M = 23.4$, $SD = 1.9$), 15 middle-aged (50 to 64 years, $M = 58.9$, $SD = 4.1$), and 15 older (65 and above years, $M = 72.9$, $SD = 7.3$) participants who were recruited from the Tallahassee, FL area. All were licensed drivers. None of the participants had participated in previous studies in our laboratory involving a similar signal: the Flashing Yellow Arrow (FYA).

Materials. A survey was programmed to be run online (exclusively in Mozilla Firefox – http://cognitivetask.com/fyp) using HTML, CSS, PHP, and JQuery. The survey consisted of six sections: (1) informed consent; (2) open response questions related to signal states while turning right; (3) open response questions related to signal states while driving straight; (4) multiple choice questions related to each signal while turning right; (5) a section asking participants for their opinion of the signal after being informed about its meaning; (6) a section containing demographic questions and questions related to driving habits. All stimuli (1000 pixels × 564 pixels) were prepared in Google Sketchup, and signal states were added in Microsoft Paint (see Fig. 2 for an example).

Fig. 2. Example stimulus, in this case depicting the FPI in its arrow phase

Images depicted an intersection from the point of view of a driver in the far right lane. This intersection had two through lanes and one dedicated left-turn lane in each direction. Since the right lane was not a dedicated right-turn lane, when the FPI was active the signal also depicted a circular green for traffic proceeding forward through the intersection. An arrow above the signal mast pointed to the four headed signal furthest to the right to ensure participants knew which signal to which they were expected to respond. For the creation of the Flashing Pedestrian Indicator animated GIFs, GifMaker.Me (http://gifmaker.me) was used, with a delay of 500 ms between frames. Timing was derived from videos of the FPI provided by the Florida Department of Transportation.

Procedure. Those that agreed to the consent form continued on to the full survey while those that did not agree were thanked for their time. For the second section, participants

were asked to interpret the meaning of each signal for a right-turning driver. Responses were collected via a text box underneath the image of the signal. Participants were asked to be as detailed as possible. The third section was essentially the same as the second, except that participants were asked to interpret the meaning of the signal for a driver going straight rather than turning right. In the fourth section, participants were asked again to interpret the meaning of the each presented signal state for a right-turning driver, but were given multiple options and were asked to check each option that applied. Options were based on information from the 2014 Florida Driver's Handbook and also discussions with FDOT regarding the intended meaning of the FPI. The options available were: (1) Come to a complete stop at the marked stop line or before moving into the cross-walk or intersection; (2) Go - but only if the intersection is clear; (3) A driver should prepare to yield to a pedestrian (if present); (4) A pedestrian is likely present; (5) A right turning driver should scan to the right for pedestrians; (6) Stop if you can safely do so, The light will soon be red; (7) A right turn is allowed. These options were randomly shuffled to control for response-order effects. For sections two through four presented above, signals were presented in the order of: (1) Green; (2) Yellow; (3) Red; (4) FPI. In the fifth section, an animation of the FPI was shown below a block of text explaining the signal. Below that, participants were asked to give their opinion of the signal, including any concerns they may have. The final section of the survey asked participants both demographic questions and questions related to their current driving habits (i.e. weekly driving distance, and frequency).

4 Results

Due to space limitations, we focus on open-ended and multiple choice response data. First, we explored the answers to open ended-questions in which participants were asked to provide the meaning of different signals. We begin with the scenario of primary interest: the meaning of the FPI for right-turning drivers. Two coders scored the answer of each participant for whether any part of the answer corresponded to the following categories: (1) the driver has right-of-way; (2) a pedestrian has right-of way; (3) a right turn is allowed; (4) a pedestrian is likely present; (5) the driver should scan or watch for pedestrian; (6) the driver should yield to a pedestrian if present; (7) the driver should slow or be cautious. In making the judgment of whether or not a driver thought a pedestrian might likely be present, we used any mention of a pedestrian as indicating awareness of potential pedestrians. Reported data represent an average of the percentage of participants providing an answer that fell within one of the previously mentioned categories across the two raters. Figure 3 depicts these results, in contrast to responses made when only the green circular of the signal above the right turn lane was active.

Encouragingly, over 90 % of participants interpreted the signal as relating to a pedestrian likely being present. Close to half (48 %) provided answers indicating that the driver should yield to pedestrians present. Fifty-four percent of participants indicated that they should scan for, slow, or be cautious in the presence of pedestrians. Few participants misinterpreted the FPI to mean that the driver had right-of-way. The two participants who made this response stated the meaning as "that you have the right away, but be safe about

the right turn lane was active.

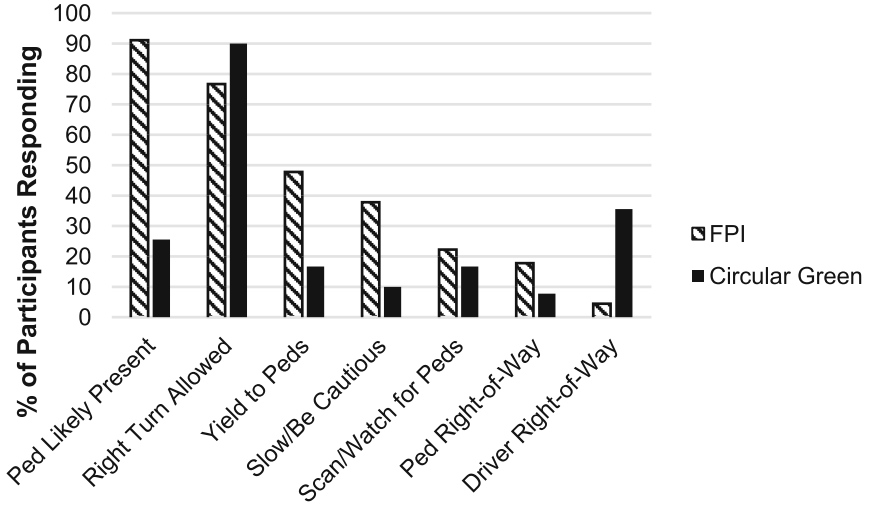

Fig. 3. Responses for drivers asked to provide the meaning of the signal for a driver turning right. Percentage of participants whose open-ended answers fell into each response category when the signal depicted the FPI (white with black bars) vs. only a circular green. (Color figure online)

pedestrian walking" and "to watch out for pedestrians even if it is my right of way." Both responses clearly indicate an awareness of potential pedestrians present and a need to be cautious. We also examined whether the distribution of responses was similar for younger, middle-aged, and older drivers and found this to be the case (Fig. 4).

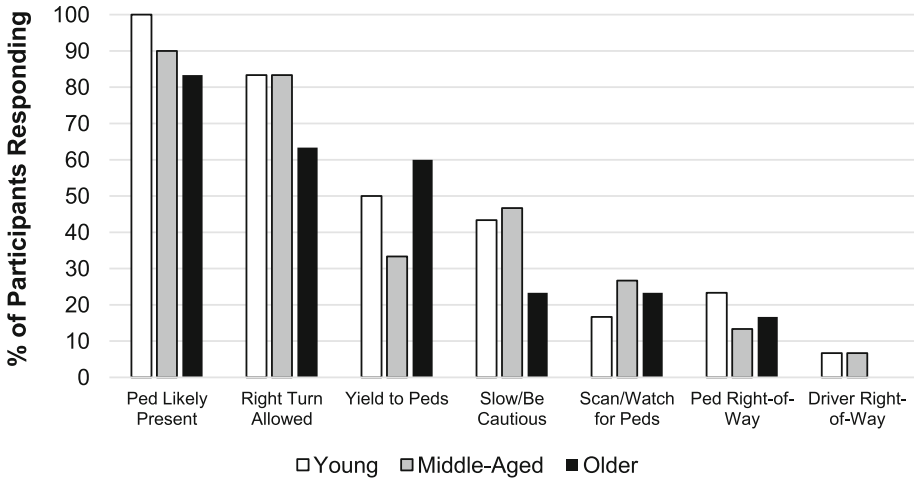

Fig. 4. Responses to the FPI for drivers turning right as a function of age

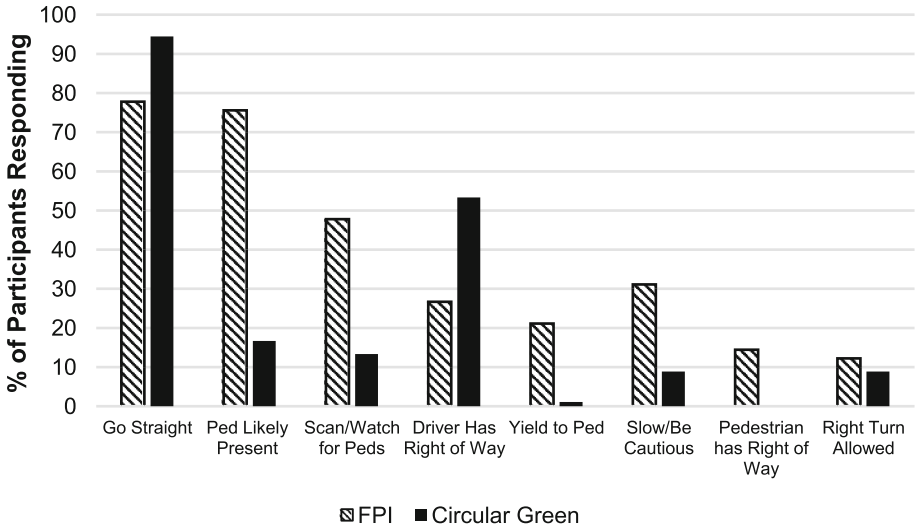

Fig. 5. Responses for drivers going straight. Proportion of participants whose open-ended answers fell into each response category when the signal depicted the FPI (white with black bars) vs. only a circular green. (Color figure online)

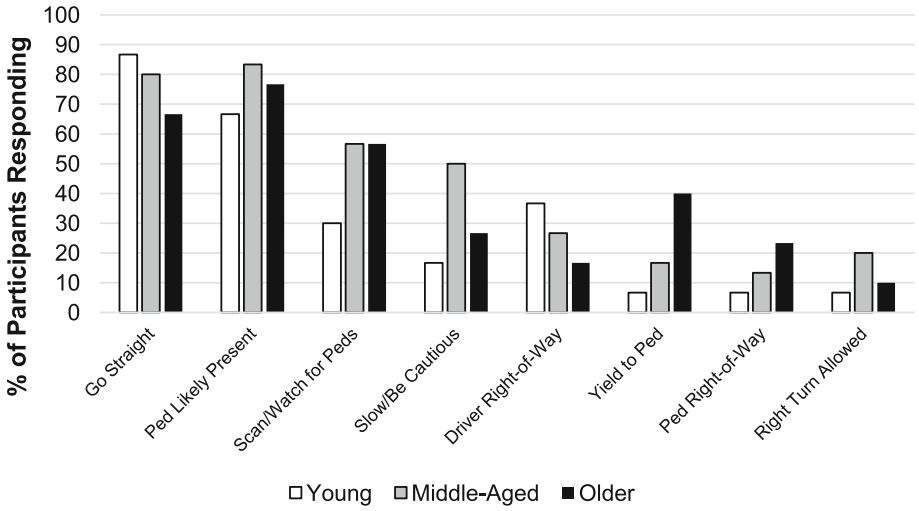

Fig. 6. Responses to the FPI for drivers going straight as a function of age

However, when presenting drivers with the same scenario, and asking the participant the meaning of the scenario for a driver going straight through the intersection, participants sometimes misinterpreted the signal as though the FPI applied to them as well (that they too needed to watch for pedestrians). Figure 5 depicts interpretation of the FPI and the circular green state for drivers going straight through the intersection. In general,

the FPI seemed to engender caution even for drivers not turning right. Figure 6 depicts a relatively similar pattern of responses across age groups.

The open-ended responses appear to confirm that most participants understood the message of the FPI well (at least for drivers turning right). Next, we explored multiple choice responses. Participants were asked, when presented with each signal state, to select all choices that applied. Within Fig. 7, we present the percent of participants who made a particular response for each signal state, including the FPI. Note that the "Go" category corresponds to the response "Go, but only if the intersection is clear."

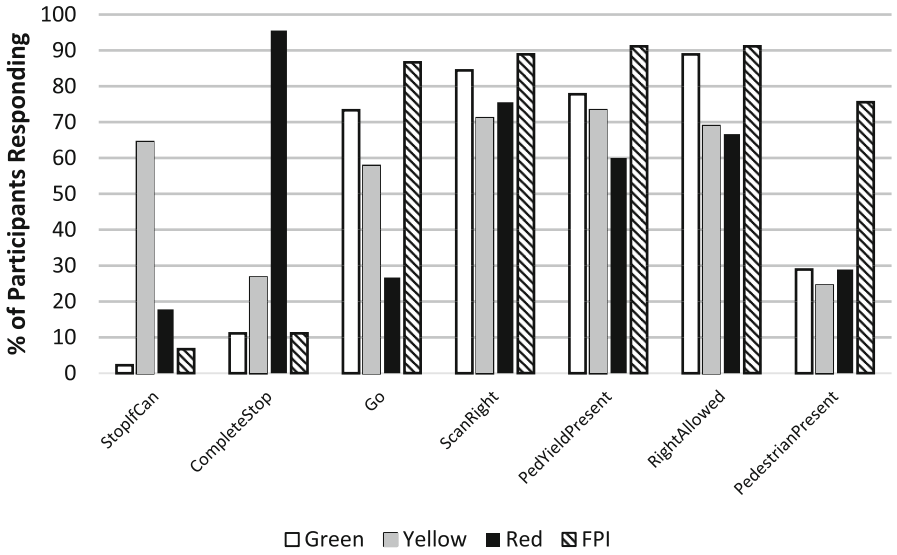

Fig. 7. Percentage of participants whose multiple choice answers fell into each response category when participants were asked the meaning of each signal for a right-turning driver. (Color figure online)

Greater than 75 % of participants understood the FPI to mean that a pedestrian may be present (far greater than any other signal; see the last set of columns to the right of Fig. 7). Greater than 90 % understood it to indicate that a driver should yield should a pedestrian be present. Although technically not the meaning of the green, yellow, and red signals, it is encouraging that a high percentage of participants indicated that a right-turning driver should yield to pedestrians and scan for participants under these conditions as well. Not surprisingly, almost all drivers indicated a complete stop should be made at the stop bar for a red signal. For a yellow signal, a mixture or responses were made, reflective of the fact that a yellow signal can mean different things depending on the context (stop if you can do so, or go if there is enough time to complete the turn). In addition to the message that a potential pedestrian was present, that they should yield if necessary, and that they should scan to the right, participants also understood that they could make a right turn in the presence of the FPI (go and right-turn allowed responses). Responses to the FPI were similar across age groups (Fig. 8).

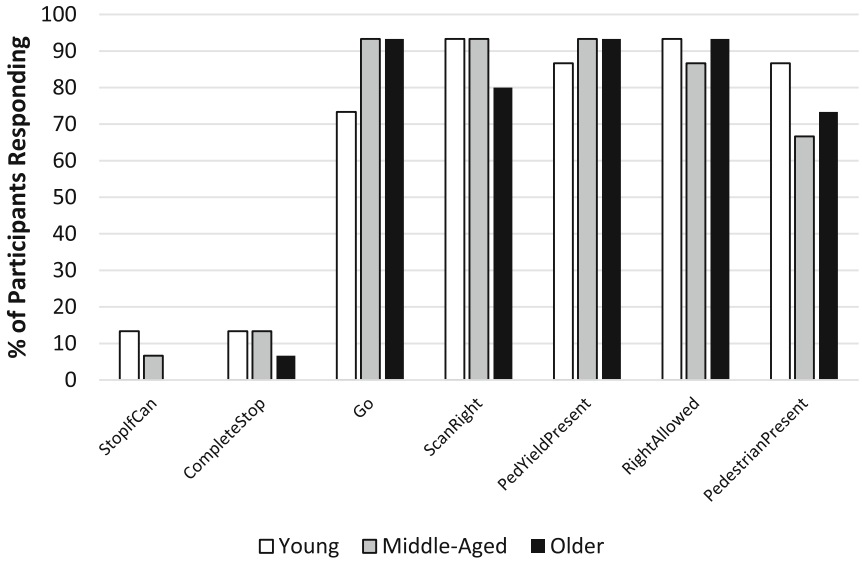

Fig. 8. Percentage of participants whose multiple-choice answers fell into each response category when participants were asked the meaning of the FPI for a turning driver as a function of age.

5 Conclusion and Discussion

The FPI was developed to reduce crashes by alerting drivers to the presence of pedestrians and encourage scanning to the right, potentially reducing instances of inattentional blindness-related crashes. When participants were asked to imagine they were a right turning driver, the FPI largely conveyed its intended meaning: in both open-response and multiple-choice formats, most participants understood that it meant pedestrians may be present, and most indicated that they should either be cautious, scan, or yield to potential pedestrians in the roadway while turning right. In the multiple choice portion of the experiment, 75 % of participants understood the signal as meaning that a pedestrian may be present, and over 90 % of participants responded that they should yield to potential pedestrians in the roadway. Comprehension was roughly similar across age groups.

When participants were asked to imagine they were driving straight the message received was mixed, with roughly 50 % of participants responding that they should scan for pedestrians. Drivers turning right, not drivers proceeding straight, should be on alert for crossing pedestrians in response to the FPI. Our study featured a scenario without a dedicated right-turn lane. Thus the FPI featured both a green circular, and the alternating yellow arrow/pedestrian figure at the same time. This mixing of signals for different drivers (those going straight, those turning) may be a contributing factor to the observed confusion. One can speculate that this confusion might be less likely to occur at intersections with a dedicated right turn lane since the FPI would only appear in the signal over the right-turn lane (without the green circular signal).

This experiment indicated that the FPI was largely well understood by right-turning drivers, and it may be worth exploring further human factors studies with the aim of reducing pedestrian crash risk. However, there may be negative consequences related to confusion for drivers proceeding straight.

Future Directions. Not all participants understood the message of the FPI in certain situations. Results allow for the recommendation of specific studies to further evaluate the FPI, such as whether confusion might be reduced in scenarios in which there is a dedicated right-turn lane. Not only can such a study measure appropriate yielding behavior during simulated driving for drivers turning right, it can also assess inappropriate behaviors (e.g., braking) in response the FPI for drivers passing straight through the intersection. A previous study examining yielding behavior in response to pedestrians within different crosswalk types might be used as a model for such a study [12].

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