The Passive Effects of Full-Gateway, In-Street Signs on Vehicular Speed

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THE PASSIVE EFFECTS OF FULL-GATEWAY, IN-STREET SIGNS ON VEHICULAR SPEED

by

De’Lon Dixon

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Master of Arts
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Thesis Committee:

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De’Lon Dixon
Reducing motorist’s speed when approaching crosswalks is an important goal in reducing the number of collision between motorist and pedestrian in crosswalks. The current study addresses this goal. The effect of gateway installation of in-street signs (one in-street sign installed between the two travel lanes in each direction and one on both edges of the roadway in each direction) on vehicle speed was evaluated on nine roads. The results demonstrated that the Gateway in-street sign treatment produced large speed reductions as vehicles approached the crosswalk and at the crosswalk. The average speed reduction was 3.8mph at the crosswalk and 2.5mph at the dilemma zone. The Gateway in-street sign variation has shown to be an effective method of reducing vehicle speed when approaching and entering the crosswalk, and these effects have sustained over time.
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INTRODUCTION

Every day, millions of Americans walk to get to work, school, convenience stores, bus stops etc. At times people are forced to walk and ride bicycles on the same roads as motorized vehicles. Pedestrians and bicyclist are the most vulnerable road users. In 2016 there were 5,987 pedestrian fatalities, on average a pedestrian was killed every hour and thirty minutes in the U.S. (NHTSA, 2018). Past research (e.g., Hunter, Stutts, Pein, and Cox, 1996) indicates that a lack of driver compliance with pedestrian crossing laws is associated with pedestrian motor vehicle crashes that ultimately result in a pedestrian fatality. There is funding available to develop interventions for many of the locations where pedestrian fatalities occur. Nationally, 67% of all pedestrian fatalities occurred on roads eligible to receive federal funding for construction or improvement, with federal guidelines or oversight for their design (Transportation for America, 2011).

There is a clear shared consensus in the traffic safety community that vehicle speed upon impact effects the risk of pedestrian fatalities. In 2011 it was reported that the risk of pedestrian fatality upon vehicle impact doubled at 31 mph compared to 24mph, and when compared to 18mph the risk was five times greater (Rosén, Stigson, and Sander, 2011). These findings demonstrate the importance of keeping vehicle speeds low in high pedestrian traffic areas. In Rosén et al.’s (2011) it was also noted that 50% of all pedestrian fatalities involved an impact speed between 31 mph and 50 mph. Therefore, reducing vehicle speed below 31 mph could reduce the possibility of pedestrian fatalities upon impact.

In the past, there have been various assessments of the risk of pedestrian fatalities. The Surface Transportation Policy Partnership, in the 1990s, developed a measurement scale to rank
the relative risk of serious pedestrian-vehicle collisions. It compensated for pedestrian exposure to create an equal playing field for comparing metropolitan areas. According to the Transportation Policy’s findings, the most prominent characteristic among dangerous sites was a failure to implement smart infrastructure investments to make roads safer. With a limited budget, the numbers of dollars that can be invested in solutions that address pedestrian vehicle collisions are restricted. This problem has been exacerbated by limited budgets due to a decreasing level of resources available to many municipalities. This results in a great amount of pressure on communities to create solutions to increase traffic safety that require fewer financial resources.

One low-cost measure that produced an initial effect that did not persist was a prompt for motorists that cued them to slow down when approaching a crosswalk. The researcher’s goal was to apply crosswalk markings to the street where heavy foot traffic occurred (Knoblauch, & Raymond, 2000). This is example of an effect that occurred, but did not sustain. Researchers measured vehicle speed before crosswalk markings and after crosswalk markings across six sites in three different states. There were 3 phases of their study: The 1st phase was no pedestrian present, the 2nd phase was the pedestrian was present and looking at vehicle, and the 3rd phase was the pedestrian was present but not looking at the vehicle. Phase 1 results indicated a 3.32 km/h (2.06 mph) reduction in speed, phase 2 resulted in a 0.28 km/h (.17 mph) reduction in speed, and phase 3 resulted in a 2.61 km/h (1.62 mph) reduction in speed (Knoblauch et al., 2000). There were changes in vehicle speeds while passing the crosswalk, but the effect was small. This study demonstrated an effect on vehicle speed; however, it did not examine how long the effect lasted, and that is an important factor when claiming behavior change.

Researchers must also take into consideration the method of data collection; vehicle speed was
measured by a trained experimenter timing vehicle speed between two marked spots approximately 180 ft (55 m) apart (Knoblauch et al., 2000).

One tool that has been shown to be effective at increasing yielding to pedestrians at crosswalks, also has promise for reducing speed as the motorist approaches and traverses the crosswalk. This is to place narrow signs prompting motorists to yield to pedestrians on the edged-lane line and the centerline of roads with signs facing oncoming traffic in street where they are highly visible to the motorist and the pedestrian (Bennett, Manal, and Van Houten, 2014). In this study, researchers looked at the effects of the Gateway treatment on motorist yielding. Yielding was measured by staged crossings. The crossing began when a researcher displayed an intention to cross the street by placing one foot within the crosswalk with his or her head turned in the direction of the approaching vehicle. A research assistant recorded the results of the trial on the clipboard. Each data collection session consisted of 20 trials (pedestrian crossings). The percentage of drivers yielding right-of-way to pedestrians was calculated for each session by dividing the number of drivers who yielded right-of-way that session by the number of drivers who yielded plus the number of drivers who failed to yield right-of-way (Bennett et al., 2014). Only drivers in the first two travel lanes were scored for yielding right-of-way after the pedestrian has entered the crosswalk. This procedure was employed, because it conforms to the obligations of motorists specified in most motor vehicle statues concerning who has the right of way, at what time. Drivers in the second half of the roadway were scored as a separate trial if there was a pedestrian refuge or median island separating the travel way. If there was no island, drivers in the second half the road were scored when the pedestrian approached the middle of the last lane before the yellow centerline of the road. This study had strong and definitive results due to the methods used. There was an increase in yielding from baseline to
treatment phase across all sites. These results indicate that the gateway is an effective mechanism to increase pedestrian safety. It is important to note that the full gateway is more effective than the partial gateway on yielding to pedestrians. The difference between the full gateway and the partial is the addition of the city post. The full gateway includes city posts which are placed on the lane lines in the full gateway and intensify the effect of the gateway (Bennett et al., 2014). Pedestrians are frequently hit because the driver operating the vehicle did not see them prior to the collision, so if vehicles are slowing down when approaching a crosswalk, they will then have more time to react. Another benefit that result from vehicle speed reduction, is the possibility of a fatal hit. The slower the vehicle is going, the lower the probability of a fatal collision. Yet, these studies did not look at the effects the Gateway has on vehicles speed. Therefore, this study will investigate the effects of the Full Gateway on vehicle speed.
METHOD

Dependent Variable

Researchers measured vehicular speeds when approaching the crosswalk at the dilemma zone and at the cross walk when a pedestrian was not present. This measure simulates the situation where a driver is approaching a crosswalk and does not see the pedestrian. The dilemma zone is a specific distance away from the cross walk, in which a vehicle should have enough time to stop for a pedestrian if they see them in the crosswalk. It is based on ITE’s signal timing formula, which takes speed, traffic volume, and road structure into account when determining the signal-light timing to ensure drivers have an sufficient amount of time to stop for traffic signals (Institute of Traffic Engineers, 2008). Approach speeds were collected in a randomly determined direction. To aide observers in discriminating the location of the dilemma zone, the location of the zone was marked by either a sprinkler flag located on the raised concrete adjacent to the road or with bright tape that extended from the raised concrete into the road. All speeds were recorded in miles per hour.

Speed data were collected using a police official LiDAR radar gun Ultra Lyte LTI 20-20 laser speed measuring system donated by the Kalamazoo Police department. The LiDAR radar gun was placed 120 feet or more away from the crosswalk on top of an adjustable tripod, in order to ensure consistency with the angles of measurement. This tripod was placed between 3 and 4 feet away from the street depending on the site, to control for cosign error. Data were collected in the same position, for each individual site. Speed data were collected during a baseline in April of 2016, after the gateway treatments were installed in June (after one month), the end of

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1 see: Crowley-Koch, Van Houten, & Lim, 2011 for a definition of how the dilemma zone is calculated.
August (the end of three months), and the end of October (at the end of 5 months). Data were also collected at some of the sites after the treatment was removed for the winter month.

**Data Collection Procedures**

A trial began when a researcher measured a vehicle’s speed at the dilemma zone and ended when the researcher measures the speed of the same vehicle at the crosswalk. When the researcher targeted the vehicle at the dilemma zone, they read the score off the radar gun to the other research assistant who recorded the speeds on a clip board. This procedure was repeated when a researcher targeted the same vehicle at the crosswalk. When the researchers were scoring vehicles, they were careful to ensure that they recorded the speed for the same vehicle at the crosswalk as they did at the dilemma zone. Vehicles were only recorded as they approached the crosswalk and entered the crosswalk. No data were recorded as they exited the crosswalk. When a group of vehicles was approaching the crosswalk, the observers only scored the first vehicle in the group.

Each data collection session consisted of collecting the speed of 200 vehicles at the dilemma zone and at the crosswalk. Each phase consisted of 2 data points (400 vehicles). Data were collected during day light hours. Data were not collected when it was raining. To prevent the observer effect, all research assistants were dressed as surveyors. This outfit consisted of a yellow hard hat, blue jeans, a safety vest, and work boots. The radar was placed on a surveyor tripod to further disguise the setup as a survey team. There were two researchers present for all data points: one researcher clocking speeds with the radar gun; the other recording the speeds on the clip board.
Scoring

Only the first vehicle in a group of vehicles was scored, because it was not possible to record the speed of multiple vehicles at the dilemma zone and again at the crosswalk with one LiDAR unit. Even if it were possible to record the speed of each vehicle, the speed of secondary vehicles would not be independent of the lead vehicle. On multi-lane roads vehicles in either of the two lands were clocked.

Data Collector Training

Researchers were trained to use the radar gun by taking speeds of a car driven by another research assistant and comparing the accuracy of the speed reading. Researchers were also taught how to fill out the data sheets, during these training session. Each researcher went through two training session prior to assisting with data collection. At each of these sessions the primary or secondary investigator was present.

Data-Collection Setup Procedure

The researchers set up the dilemma zone before beginning trials. A walking wheel was used to measure the distance from the nearest crosswalk line to the dilemma zone. During the marking process, one of the researchers served as a spotter to ensure that the person using the walking wheel was clear of traffic. Both researchers wore an orange safety vest during the marking process. The researchers then marked the location of the dilemma zone with the necessary flags and/or tape. After the data has been collected, the assistants collected the flags using the same spotter safety procedures.

The researchers set up the radar gun and tripod before beginning trails. A walking wheel was used to measure the distance back from the nearest crosswalk line to one hundred and
twenty feet away. When that distance was measure the radar gun was placed within 3 to 5 ft of the roadway. This ensured they were measuring the vehicle at an angle that made any co-sign trivial. That being said, researches made it standard to collect from one hundred twenty feet or beyond.

**Inter- Observer Agreement**

Since there could only be one research assistant, at a time, reading the speed from the radar gun, we could not gather IOA on that measure. However, IOA should not be required for this type of error because this is essentially the same procedure used to record data off counters in an EAB lab. It also has judicial notification and will stand up in courts all over the US. The researcher calibrated the radar gun prior to data collection in the manner described by the manufacturer. This method also has judicial approval. The calibration instruction can be found in the LTI 20-20 UltraLyte 100 user manual (Laser Technology Incorporated/ Tele- Traffic, 2007).

**Participants**

The participants were motorists using the road when pedestrians were not present in the crosswalk. Only thru vehicles were measured, vehicles that stopped after the crosswalk to park or turn off the roadway were not recorded. A driver would become a participant by operating a motor vehicle in the designated research site. Participants did not have to meet any additional selection criteria. Motorist demographic information was not recorded. Information about motorists’ vehicles was not recorded. A record of participants in the study and participant driving behavior did not exist.
EXPERIMENT

Description of Sites

There were 10 crosswalk sites in this study, seven of which were located on multi-lane roads. The first site was a crosswalk near Wealthy Street and Henry Avenue in Grand Rapids Michigan. Wealthy Street had one travel lane in each direction. The area around the sidewalk had various restaurants and bars near it. The speed limit at this site was 25 mph. The second site was a crosswalk near Cherry Street and Hollister Avenue in Grand Rapids Michigan. Cherry street had one travel lane in each direction. The roads were paved with bricks and the surrounding area had single family houses and a book store. The speed limit at this site was 25 mph. The third site was a crosswalk at Westnedge Ave and Ranny Street in Kalamazoo Michigan. Westnedge Avenue was a 2-lane road with traffic going in one direction. The surrounding area consisted of restaurants and housing. The speed limit at this site was 35 mph.

The forth site was 7th Street & Stadium Blvd near Pioneer High School in Ann Arbor, MI. The site had two lanes, one going in each direction and a bike lane in each direction. The lanes were separated by a median approximately 10 ft. wide. On one side of the street was a bus stop, along with a wooded area with a trail. Pioneer High School was located on the other side of street. The speed limit on 7th street is 35 mph. The fifth site was Huron Road and Thayer Street in Ann Arbor, MI located on University of Michigan’s campus. This site was a multi – lane road with two lanes of traffic going in each direction for a total of 4 lanes. There was a midblock refuge island separating the two directions of traffic. Campus auditoriums were on one side of the street, and student housing was on the opposite side of the street. The speed limit on Huron is 30 mph. The sixth site was on Division Street at Jefferson Street in Ann Arbor, MI. This crosswalk is located on University of Michigan’s campus. Division Street is a 3-lane one way
street. The surrounding area consisted of housing and a parking garage. The speed limit on Division Street is 30 mph.

The seventh site was Nixon Road and Bluett Street in Ann Arbor MI. Nixon Road had 3 lanes, 2 lane going in one direction, one of which was a turn lane, and one lane in the opposite direction. There was housing on both side of Nixon Road. The speed limit on Nixon Road was 30 mph. The eighth site was a midblock crosswalk on North Main Street in Three Rivers, MI. This site was located in downtown Three Rivers, Main Street has two lanes of traffic, one lane going in each direction. The surrounding area consisted of shops and restaurants. The speed limit on Main Street is 30 mph. The 9th site was Monroe Street in Allegan, MI. This site had two lanes, one going each direction. The two lanes were separated by a midblock pedestrian refuge island. The surrounding area included a skate park and police station on one side, and housing on the other. The speed limit on Monroe Street is 30 mph. The 10th site was West Main Street Benton Harbor, MI. This site was a two lane road with one lane in each direction. This site was located at a roundabout with three exits. The surrounding area included a grocery store, and the headquarters of a large company. The speed limit at this site was 30 mph.

**Experimental Design**

A reversal design was used in this experiment. Baseline were collected in the absence of the full gateway. During the first condition the full gateway was introduced across all sites. This included 3 in-street signs, 1 sign on the lane line separating two lanes carrying vehicles in one direction, and 2 signs installed on each side of the road, one on the gutter pan or curb on the right side of the road and the other on the gutter pan or curve on the left side of the road. Conditions 2 and 3 were identical to condition 1, data were just collected to see how well the effect persisted.
over time. To make a gateway all edges of the roadway and every lane line will have signs placed on them. The 4\textsuperscript{th} condition was a return to baseline and all signs were removed.

**Phase Description**

During the baseline condition there were no in-street signs in the road. This condition is illustrated in Figure 1. An in-street sign was installed to separate travel lanes in each direction and signs were installed on the gutter pans on the side of the road and next to the median island. There was also a city post placed besides each sign. This configuration of signs in the center and both sides will be referred to as the Gateway treatment and is illustrated in Figure 2. At our Three Rivers site we added a unique feature to the gateway, city posts were added in addition to the gateway, these are the lime green poles you see next to the each of the signs in Figure 2. An in-street sign was installed to separate travel lanes in each direction and signs were installed on the curb on the side of the road and next to the median island. This configuration of signs in the center and both sides will be referred to as the Gateway treatment as well, although the signs were placed on the curb and not the gutter pan. This configuration is displayed in Figure 3. 2 in-street signs were installed to separate travel lanes in each direction and signs were installed on the curb or gutter pan on the side of the road and next to the median island. This configuration is displayed in Figure 4. For the sites with 3 lanes, an in-street sign was installed to separate travel lanes in each direction and signs were installed on the lane line on the side of the road. There was also a city post placed on the lane line between the left turn lane and the lane. This configuration is displayed in Figure 5. Some of our sites were on multi-lane roads, this configuration is displayed in Figure 6.
Figure 1. No Gateway Present

Figure 2. Gateway Signs in Gutter Pan.
Figure 3. Gateway Signs on Curb

Figure 4. Partial Gateway

Figure 5. Gateway 3 Lane Road
The results of this study for all sites are presented in table 1. This table displays the baseline speed measure, and the speed measures obtained after the gateway was introduced in June, August, and October and then the return to baseline speed measures in November and December. Driving speeds decreased after the gateway was installed at all 10 crosswalk locations. There are multiple sites that have “n/a” in the speed measures box. At those sites, the researchers were unable to collect the data for that phase. At the Westnedge Ave & Ranney Street site, there was sign damage in phase 3 and then the signs remained up throughout the return to baseline phase. At Monroe Street in Allegan, the signs remained installed during the return to baseline phase, so it was not possible to collect reversal data. At Division & Jefferson, the city began construction on the road, so we were unable to collect data for phase 3 and return to baseline. Lastly, on Huron in Ann Arbor, we were unable to collect return to baseline data because the city left the signs installed. Sites with baseline speeds below 25 mph showed the smallest effect size.
Table 1. Mean Vehicle Speed at the Dilemma Zone and Crosswalk at Each Site

<table>
<thead>
<tr>
<th>Site</th>
<th>Basline Mean Speed</th>
<th>TX1 June Mean Speed</th>
<th>Tx2 Aug Mean Speed</th>
<th>Tx3 Oct Mean Speed</th>
<th>Return to Basline Nov-Dec Mean Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW Michigan</td>
<td>Dilemma Zone</td>
<td>Crosswalk</td>
<td>Dilemma Zone</td>
<td>Crosswalk</td>
<td>Dilemma Zone</td>
</tr>
<tr>
<td>Westnedge &amp; Ranney</td>
<td>3.57</td>
<td>28.95</td>
<td>24.34</td>
<td>22.97</td>
<td>28.06</td>
</tr>
<tr>
<td>Three Rivers N.Main</td>
<td>23.93</td>
<td>22.64</td>
<td>21.56</td>
<td>21.54</td>
<td>23.96</td>
</tr>
<tr>
<td>Benton Harbor</td>
<td>29.39</td>
<td>19.22</td>
<td>27.61</td>
<td>18.80</td>
<td>27.40</td>
</tr>
<tr>
<td>Monroe</td>
<td>27.11</td>
<td>28.12</td>
<td>25.90</td>
<td>21.57</td>
<td>27.15</td>
</tr>
<tr>
<td>Grand Rapids</td>
<td>Cherry &amp; Hollister</td>
<td>25.57</td>
<td>25.25</td>
<td>22.76</td>
<td>21.89</td>
</tr>
<tr>
<td>Wealthy &amp; Henry</td>
<td>24.76</td>
<td>24.385</td>
<td>24.41</td>
<td>21.97</td>
<td>24.74</td>
</tr>
<tr>
<td>Ann Arbor</td>
<td>7th &amp; Stadium</td>
<td>30.25</td>
<td>33.87</td>
<td>31.62</td>
<td>27.64</td>
</tr>
<tr>
<td></td>
<td>Division &amp; Jefferson</td>
<td>28.05</td>
<td>27.42</td>
<td>25.35</td>
<td>19.13</td>
</tr>
<tr>
<td></td>
<td>Nixon &amp; Bluett</td>
<td>33.38</td>
<td>32.28</td>
<td>30.40</td>
<td>28.68</td>
</tr>
<tr>
<td></td>
<td>Huron</td>
<td>32.84</td>
<td>32.92</td>
<td>29.42</td>
<td>28.32</td>
</tr>
</tbody>
</table>

Mean speed reductions as the vehicle traversed the crosswalk for all sites with a baseline mean speed of 25 mph or more are shown in Table 2. These data show that the speed reductions at these sites averaged around 4 mph and remained consistent over the 5-month measurement period. These data show that drivers began to slow at the dilemma zone and that the mean reduction in speed varied between 2 and 3 mph. This would imply that drivers might not be expected to engage in hard braking because they begin slowing at a reasonable distance when approaching the gateway. Huron Road in Ann Arbor displayed the largest effect over the course of the experiment, with a speed reduction at the crosswalk of 9.4 mph in August. East Main Street in Three Rivers showed the smallest effect with a reduction of .42mph in June.
Table 2. Vehicle Speed Reduction at the Dilemma Zone and Crosswalk

<table>
<thead>
<tr>
<th>Locations</th>
<th>Speed Reduction at Crosswalk</th>
<th>Speed Reduction at Dilemma Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monroe</td>
<td>2.7</td>
<td>1</td>
</tr>
<tr>
<td>Stadium</td>
<td>3.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Huron</td>
<td>4.6</td>
<td>9.4</td>
</tr>
<tr>
<td>Westnedge</td>
<td>6.1</td>
<td>N/A</td>
</tr>
<tr>
<td>Nixon</td>
<td>3.6</td>
<td>3</td>
</tr>
<tr>
<td>Divison</td>
<td>8.3</td>
<td>7.9</td>
</tr>
<tr>
<td>Cherry</td>
<td>3.3</td>
<td>4.7</td>
</tr>
<tr>
<td>Wealthy</td>
<td>2.42</td>
<td>0.75</td>
</tr>
<tr>
<td>East Main</td>
<td>0.42</td>
<td>3.57</td>
</tr>
<tr>
<td>North Main</td>
<td>1.08</td>
<td>8.68</td>
</tr>
<tr>
<td>Mean</td>
<td>3.57</td>
<td>4.54</td>
</tr>
</tbody>
</table>

DISCUSSION

The results of this study show that the presence of the Gateway in-street sign configuration was associated with a reduction in speed when vehicles were approaching the crosswalk and entering the crosswalk. These data also show that the Gateway treatment can produce effects on multilane roads, one-way roads and roundabouts.

There are several important findings. First, the reduction in mean driver speed was relatively large and similar or better than various alternative traffic calming methods. This is critical because driver speed is correlated with the probability of a pedestrian crash as well as the severity of a pedestrian crash. The speed a driver crosses when a pedestrian is not present is important, because it is also the speed present when a driver does not see a pedestrian in a crosswalk or only sees them at the last moment when there is less time to react. Another discovery was that drivers began to reduce vehicle speeds at the dilemma zone. This finding is important because gradual slowing decreases the probability and potential severity of a rear end crash with the following driver.
Research suggests that the gateway treatment produces these effects by making the crosswalk more visible. Vehicles slow down when approaching the crosswalk because the gateway in the street is visible at a considerable distance, so drivers need to slow down to ensure they don’t damage the sign nor their vehicle. The drivers’ slowing prevents their vision from being narrowed so they can see pedestrians attempting to cross; and they also have more time to react.

One disadvantage to the Gateway is that the signs are located in the street, and at some location these signs would get in the way of snow removal, so the signs would have to be removed during the winter in regions with snowfall. A potential replication could investigate the effects the gateway has when all signs are placed on the curb or on the median. This study would determine whether a partial gateway located on curbs would still produce the same reductions in speed and increase in yielding behavior. These findings could also determine whether a partial gateway would be of benefit in cities with high levels of snowfall.
REFERENCES


