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Use of a Gateway In-Street Sign Treatment to Increase Yielding to Pedestrians at Crosswalks

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USE OF A GATEWAY IN-STREET SIGN TREATMENT TO INCREASE
YIELDING TO PEDESTRIANS AT CROSSWALKS

by

Miles K. Bennett

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Master of Arts
Department of Psychology
Western Michigan University
June 2013

Thesis Committee:

Ron Van Houten, Ph.D., Chair
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USE OF A GATEWAY IN-STREET SIGN TREATMENT TO INCREASE YIELDING TO PEDESTRIANS AT CROSSWALKS

Miles K. Bennett, M.A.

Western Michigan University, 2013

An important goal to reduce the number of collisions between motorists and pedestrians is to increase motorist's yielding right-of-way to pedestrians in crosswalks. The current study addresses this goal. A 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) was evaluated on multilane roads. The first experiment compared the efficacy of adding multiple in-street signs used in a gateway configuration with a single sign between the two travel lanes in each direction. The second experiment compared the in-street sign gateway treatment with a more expensive Pedestrian Hybrid Beacon. The results demonstrated that the Gateway in-street sign treatment produced very high levels of drivers yielding behavior, and that the Gateway treatment was as effective as the more expensive treatment.

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Miles K. Bennett

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INTRODUCTION

Millions of Americans walk every day to get to school, work, grocery stores, bus stops, etc. Pedestrians have to share the road with cars, busses, bicycles, motorcycles, and the many other forms of motorized transportation. Pedestrians along with bicyclists are the most vulnerable road users. In 2010, there were 4,280 pedestrian fatalities and over 70,000 injuries in the U.S. (NHTSA, 2012). In 2009 1,468 pedestrians were killed in Michigan and 799 of these deaths occurred in the Detroit-Warren-Livonia Area (Transportation for America, 2011). Past research (e.g., Hunter, Stutts, Pein, and Cox, 1996) indicates that a lack of driver compliance to 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 are a variety of measures used to understand pedestrian fatalities. The Surface Transportation Policy Partnership in the 1990s developed a measurement scale to rank the relative risk of serious pedestrian-vehicle collisions compensated for pedestrian exposure in order to establish a level playing field for comparing metropolitan areas. According to the Partnerships findings, the reoccurring characteristic among dangerous sites was a failure to make smart

infrastructure investments to make roads safer. With a limited budget, the numbers of dollars that can be invested into solutions that address pedestrian-vehicle collisions are limited. This problem has been exacerbated by reduced spending due to a decreasing level of economic resources available to many municipalities. This puts increased pressure on communities to create solutions to increase traffic safety that require fewer financial resources.

This problem of pedestrian safety has been approached in different ways. Historically, there has been legal action taken to try and ensure the safety of pedestrians. The Michigan Vehicle Code section 257.612 (ii) states, “The vehicular traffic shall yield the right of way to pedestrians lawfully within an adjacent crosswalk and to other traffic lawfully using the intersection.” Despite this law, motorists often fail to yield right-of-way to pedestrians. Some studies have examined ways to increase the occurrence and efficacy of driver compliance with pedestrian right-of-way laws (Van Houten, Malenfant, Blomberg & Huitema, in press; Van Houten and Malenfant, 2004; Van Houten & Malenfant, 1989). Several inexpensive engineering approaches have been designed to increase safety at crosswalks. Several studies have shown that signs and markings can reduce the occurrence of evasive conflicts between motorists and pedestrians (near crashes). For example, signs, pavement markings to encourage drivers to yield further in advance of the crosswalk, and beacons to alert drivers that a pedestrian is crossing have been shown to reduce conflicts between motorists and pedestrians and increase yielding behavior (Huybers, Van Houten, Malenfant,

2004; Malenfant, & Van Houten, 1990; Van Houten, 1988; Van Houten, & Malenfant, 1992, Van Houten, et. al., 2003).

A particularly effective way to prompt motorist's to yield right-of-way is to place narrow prompting signs in the middle of the street where they are highly visible to the motorist and the pedestrian (Kannel & Souleyrette, 2003). A "STATE LAW YIELD FOR PEDESTRIANS sign placed in the roadway is referred to in the Manual on Traffic Control Devices (MUTCD) as an in-street sign (R1-6 sign) (MUTCD, 2009; page 55). Researchers suggest that the signs may be effective in part because it serves as a visual prompt to road users on laws regarding right-of-way at unsignalized pedestrian crosswalks. This sign has been shown to be effective at increasing motorist yielding right-of-way to pedestrians in crosswalks on roads with one lane in each direction (Ellis, Van Houten, & Kim, 2007). However many roads have more than one lane in each direction (also known as multi-lane roads). When used on multi-lane roads the in-street sign is typically placed on the lane line separating the two travel lanes in each direction. These signs have only proven to be moderately effective on multilane roads in the past (Turner, Fitzpatrick, Brewer, & Park, 2004).

Previous research suggested that there is no advantage gained by installing multiple signs (Ellis, Van Houten, & Kim, 2007). However these signs were installed sequentially in the same location, all of them on the centerline (one 40 ft in advance of the crosswalk, one 20 ft. in advance of the crosswalk, and one at the crosswalk). An alternative way to install multiple in-street signs would is to install them in different locations across the road rather than all in the same location. For

example, on a multilane road with two travel lanes in each direction an in-street sign could be installed between the two travel lanes in each direction, and on the right side of the right travel lane and the left side of the left travel lane. Such a configuration, or a gateway configuration, should be more visible to all motorists and would produce an apparent narrowing of the travel-way. Therefore purpose of the first study is to compare the efficacy of adding multiple in-street signs used in a gateway configuration with a single sign used between the two travel lanes in each direction on two multilane roads.

METHOD

Dependent Variables

Researchers measured the number of motorists who did and did not yield to pedestrians in crosswalks, and the percentage of motorists who yielded at various distances in advance of the crosswalk. Driver yielding behavior was measured in reference to an objective dilemma zone (see: Crowley-Koch, Van Houten, & Lim, 2011) for a description of how the dilemma zone was calculated). 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.

Motorists who had not passed the outer boundary of the dilemma zone when a pedestrian entered the crosswalk were scored as yielding or not yielding because they had sufficient time and space to stop safely for the pedestrian.

Motorists who entered the dilemma zone before the pedestrian or researcher

placed a foot in the crosswalk could be scored as yielding but could not be scored as failing to yield because the motorist did not have sufficient time and/or distance available to yield safely to the pedestrian attempting to cross.

The distance from the edge of the crosswalk that a motorist yielded was measured by placing marks on the curbs with tape and/or flags in a similar fashion as the dilemma zone boundary. These distances were; greater than 30 feet in advance of the crosswalk, between 20 and 30 feet in advance of the crosswalk, between 10 and 20 feet in advance of the crosswalk, and less than 10 feet in advance of the crosswalk. The position of the motorists' vehicle was determined by taking the distance when the pedestrian crossed the lane the yielding motorist's vehicle was traveling in.

Data Collection Procedures

A trial, or staged 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(s). 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 that yielded right-of-way that session by the number of drivers that yielded plus the number of drivers that failed to yield right-of-way.

Scoring

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 statutes on 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. Data were collected during day light hours. Data were not collected when it was raining.

Data Collector Training

Researchers were trained to use the operational definition of yielding behavior. Researchers practiced recording together until they obtained inter-observer agreement (IOA) of 90% or better for two consecutive data sheets. Researchers were also be trained on how use a walking wheel to measure the distance to the dilemma zone, and how to install the flags or lay the tape.

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 persons wore orange vests during the marking process to make them more visible to drivers. The researchers then marked the location with the necessary flags and/or tape. After the data has been collected, the assistants collected the flags using the same spotter safety procedures.

Inter-Observer Agreement

IOA was calculated for 20% of the sheets collected and data were collected during each condition of the experiment. Each event that was scored the same by both observers was counted as an agreement and each event that was scored differently by each observer was scored as a disagreement. IOA was then calculated by dividing the number of agreements during each session by the number of agreements during that session plus the number of disagreements for that session. The result of this calculation was then be multiplied by 100 to obtain an IOA percentage score.

During sessions in which agreement data were collected, the two observers would stand several meters apart at a location with an unobstructed view of the crosswalk. When more than one pedestrian crossed at a particular crosswalk, the primary observer identified the pedestrian for whom yielding behavior was to be scored.

Participants

The participants were motorists using the road when pedestrians were crossing in the crosswalk. 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. As a result, there was no information to be made confidential. Participants were not required to sign a statement of agreement or informed consent because special permission

was received to collect information about drivers from the State of Michigan through the Michigan Department of Transportation.

EXPERIMENT I

Description of Sites

The first site was crosswalk near 4 East Holden Hall Trowbridge Road in East Lansing, MI on the Michigan State University campus. Trowbridge Road had two travel lanes in each direction separated by a median island. Vehicles on the two lanes on the north side of the crosswalk were travelling east to west and motorist on the south side of the crosswalk were travelling from west to east. The area around the sidewalk had trees on either side of the road approaching the crosswalk, but not near the crosswalk itself. The median island separating both half of the roads was approximately 25 feet in length. The speed limit was 30 mph.

The second site was a crosswalk near 33199 Grand River Avenue in Farmington Hills, MI. The road here consisted of 3 lanes. There were two lanes in one direction and one in the opposite direction. A double yellow line separated the two directions of travel and there was no island separating the travel lane in each direction. The two lanes of traffic moved from east to west and the one lane of traffic moved from west to east. The speed limit was 25 mph. At this site data were only collected in the direction that carried two lanes of traffic.

Experimental Design

A reversal design was be used in this experiment. Baseline was collected in the absence of the in-street signs. During the first condition one in-street sign

was installed on the lane line separating two lanes carrying vehicles in one direction. During the gateway treatment two additional in-street signs were installed on each side of the road, one on the gutter pan on the right side of the road and the other on the gutter pan on the left side of the road) on Trowbridge, and one on each side of the road carrying two lanes of traffic and one between the two lanes at the Farmington Hills site.

Phase Descriptions

During the baseline condition there were no in-street signs in the road. During the standard in-street sign condition only one in-street sign was installed separating the two travel lanes in each direction on both half of the road. This configuration is illustrated in the left frame of Figure 1. An in-street sign was installed to separate travel lanes in each direction as in the previous condition and signs were also installed on the gutter pans 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 and is illustrated on the right frame of Figure 1. Figure 2 shows how the Gateway treatment is installed at a site where there is no gutter pan on one side of the road.



Figure 1. Gateway with gutter pan.



Figure 2. Gateway without gutter pan.

Results

The results of this study for the Trowbridge Road site in East Lansing, MI site are presented in Figure 3. Yielding at this site averaged 25% during the baseline condition when no signs were present, 57% with one in-street sign present, and 79% with the Gateway treatment present. These results indicated that the single in-street sign treatment produced more yielding than the baseline condition and that Gateway treatment was more effective than the single in-street sign condition.

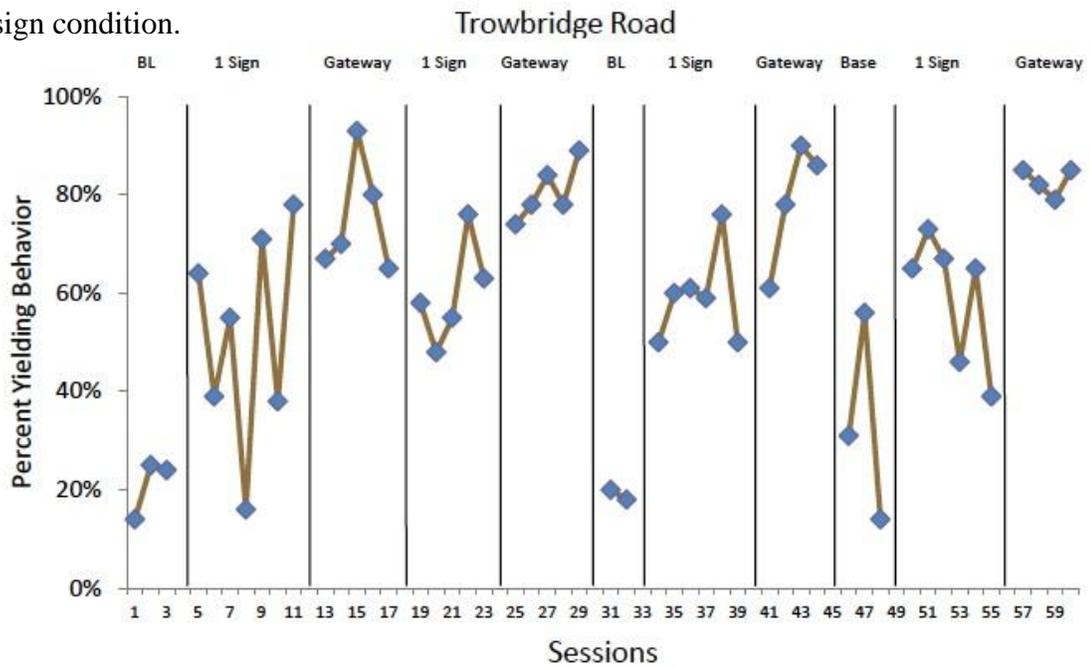


Figure 3: Trowbridge results.

Data from the Farmington Road Site are presented in Figure 4. During the baseline condition when no signs were present 25% of motorists yielded to pedestrians. Yielding increased to 57% during the one sign condition and to 82% during the Gateway condition. These results indicated that the Gateway treatment was more effective than the single sign condition at this site, as well, and that it produced similar yielding to that obtained at the East Lansing, MI site.

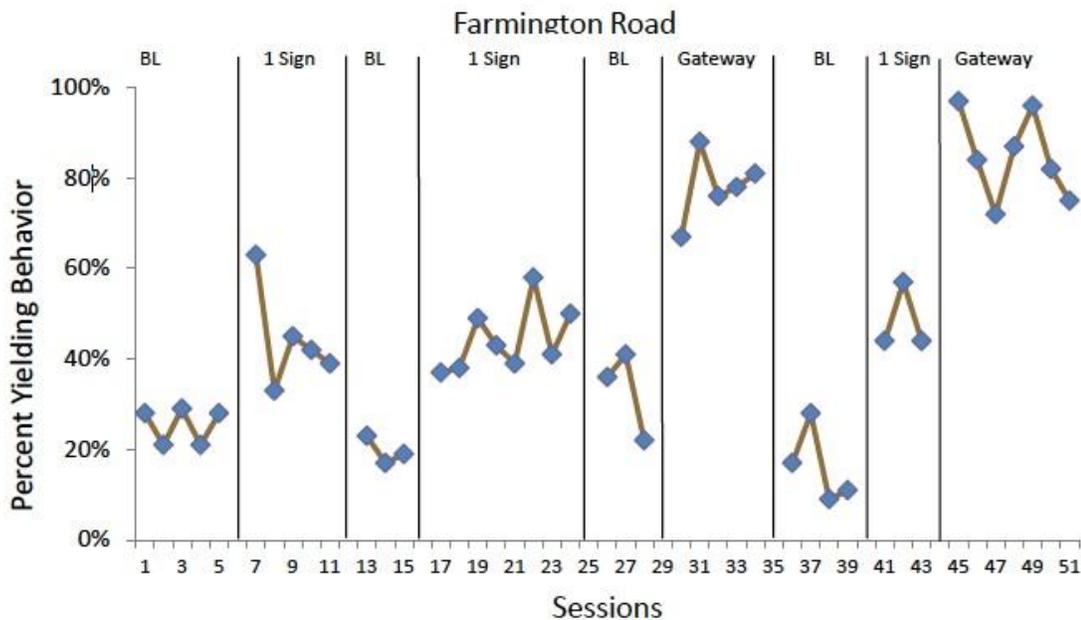


Figure 4: Farmington results.

Discussion

The results of Experiment 1 demonstrated that a Gateway treatment of the in-street signs produced a level of yielding similar to those produced by more expensive traffic control devices. One reason why the Gateway treatment was so effective may have been the perceived narrowing of the roadway produced by adding signs in the gutter pan area or the edge of the road outside the travel way. It is also likely that three signs likely were more visible than one sign particularly if vehicles ahead of a motorist approaching the crossing screens one or more of the signs. Gutter pan placement also may be less prone to being struck by vehicles

thereby contributing to a longer life of the signs. The data collection period took place over 3 months at the site located in Farmington Hills, MI and 2 months at the East Lansing, MI site.

Because the data was collected over months, the data also captures the effectiveness of the intervention over time. Some of the highest yielding behavior was recorded on the last day of the last Gateway phase. The Gateway treatment is hypothesized to decrease the perceived width of the roadway. Because of the location of the signs, the road itself is not actually narrowed. These signs may also provide better delineation of the edge of the roadway when they are present. Specifically the boundaries of the road are extended vertically via the signs. A driver may ignore the boundaries of the road while driving. However, when the visual approximations are made more salient, it may cause the driver slow down. However, no data were collected on vehicle speed in this series of studies.

EXPERIMENT II

Another successful intervention for increasing yielding right-of-way for pedestrians in crosswalks is the Pedestrian Hybrid Beacon (PHB) (Fitzpatrick et. al study). A PHB is a pedestrian activated beacon developed in the late 1990s (see Figure 5). It has two signal heads with two red lenses over a single signal head with a yellow lens. Both are located along the medians of the lanes, suspended from a mast arm or span wire over the crosswalk. There is a button system attached to the mast arm or pole on the sidewalk. Once a pedestrian presses the button the PHB begins a sequence to signal the motorist. First the

yellow light flashes, then the light turns solid yellow. After the yellow clearance interval the two red lights activate and stay illuminated for a short period of time while a pedestrian signal head shows a walk symbol. The two red lights then begin to alternate flashing in a wigwag pattern and the pedestrian will see a count down timer. An evaluation of the PHB at 21 sites and an additional 102 reference sites found a 13% and 29% reduction in all crashes and approximately 50% reduction in pedestrian-vehicle crashes (Fitzpatrick and Park, 2009).



Figure 5: Pedestrian hybrid beacon.

Although the PHB has been shown to be highly effective, it is relatively expensive to install. The installed cost of the PHB varies between \$60,000 and \$100,000. This cost is subject to a variety of factors including existing infrastructure in place and the geometry of the crossing location. Therefore, costs in some cases are sometimes higher. In contrast the installed cost of in-street signs is currently \$300 a piece. The purpose of Experiment 2 is to compare the in-street

sign gateway treatment with the PHB and the effects of combining a single in-street sign with the PHB.

Two sites with a PHB installed were evaluated in this experiment. The first sets of data were collected from a crosswalk located near 19139 Livernois Avenue in Detroit, MI. This site has an island of separating the two travel lanes in each direction. Traffic on the two east lanes moved from north to south and traffic on the west two lanes move from south to north. There was parking located on both sides of the road and trees dotting the sidewalks. The speed limit is 30 mph at this site.

The second PHB was a midblock crosswalk located at 5474 Cass Road in Detroit, MI. This crosswalk had four lanes of traffic, two lanes in each direction and did not have an island or median. Traffic moved from north to south in the two westbound lanes and from south to north in the two eastbound lanes. There were some trees near the sidewalk and but less than all the other sites. The speed limit was 25 mph. Because both sites are located in the same city, they will be referred to as Livernois Avenue site and the Cass Road site.

Experimental Design

A reversal design was used in this experiment. The baseline condition consists of crossings when there were no in signs in the road and the PHB is not activated. The one sign condition had one sign separating travel lanes in each direction and the PHB was not activated. During the PHB alone condition there were no in-street signs in the road and the PHB was activated for each crossing. The sign plus PHB condition had one in-street sign separating the travel lanes in

each direction and the PHB was activated for each crossing. The Gateway treatment condition had three in-street signs in each direction and the PHB was not activated. The Gateway treatment was not evaluated at the Cass site because the single sign plus PHB yielded very high levels at this site.

Results

The results of the Livernois Avenue site are presented in Figure 6. Yielding at this site averaged 1% during baseline (crosswalk markings alone) condition, 37% during the one in-street sign alone condition, 62% during the PHB alone condition, 85% during the in-street sign plus PHB treatment condition, and 72% during the Gateway alone treatment. These results indicated that the PHB alone was more effective than the in-street sign alone, but the Gateway treatment was equal to or more effective than the PHB alone condition. The PHB plus the in-street sign was the most effective of the treatments producing 13% more yielding than the Gateway treatment alone.

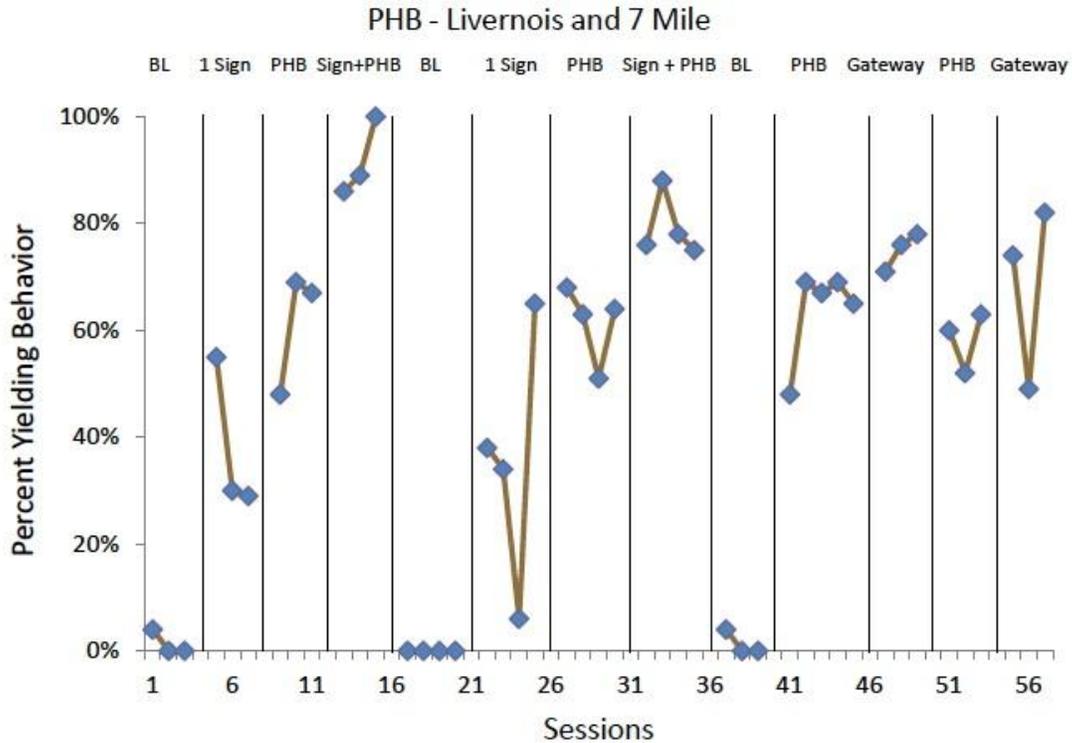


Figure 6: Livernois and 7 Mile results.

The results for the Cass Road site are presented in Figure 7. Yielding at this site averaged 10% during the baseline (crosswalk markings alone) condition, 84% during the PHB condition alone condition, and 94.5% during the PHB plus one in-street sign condition. Even though yielding for the PHB was far better at this site than the Livernois Avenue site, the addition of a single the in-street sign in each direction separating the lane lines still increased yielding to higher levels. This site was on the Wayne State University campus where the posted speed limit was 25 mph. At the Livernois Avenue site the speed limit was 30 mph, and less yielding was obtained during both the marked crosswalk alone condition and the PHB activation conditions.

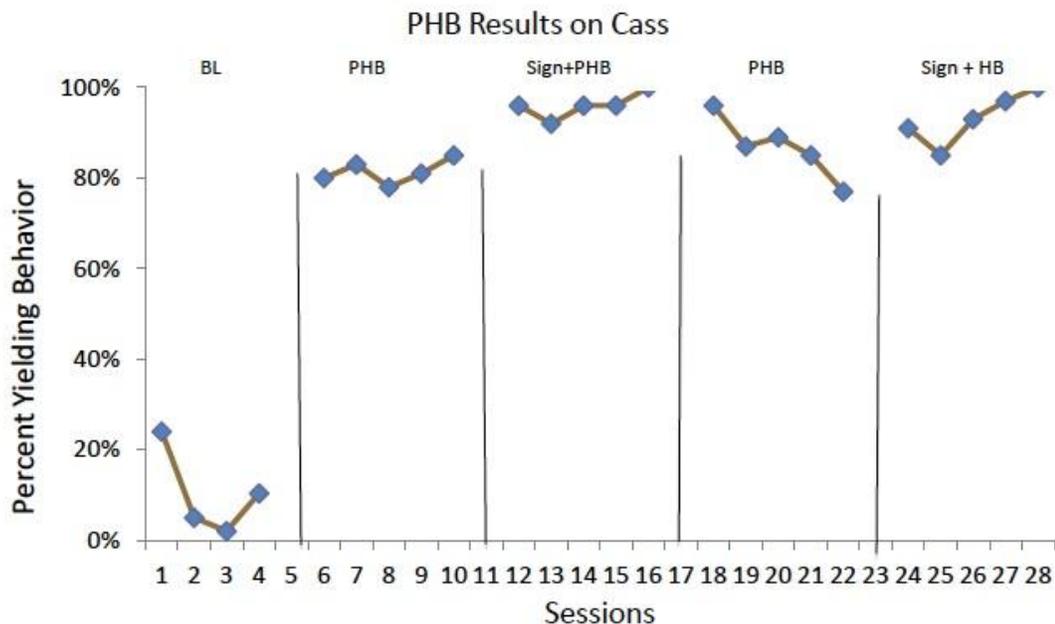


Figure 7: PHB results on Cass.

Discussion

These results show the addition of an in-street sign at both sites increased yielding behavior to higher levels than the PHB alone, and that the Gateway treatment was as effective as more expensive PHB alone at the Livernois site. The Gateway treatment was not needed at the Cass Site because the PHB plus one in-street sign produced near perfect yielding behavior. This is likely because of the lower speed limit this site. However, it is likely that the Gateway treatment alone would have also produced excellent results at this site.

GENERAL DISCUSSION

The results of this study show that an existing pedestrian improvement, the PHB in this case, can produce large increases in yielding on their own and that they can be further enhanced by the presence of a single in-street sign in each

direction. These data also show that the use of the in-street sign as a Gateway treatment can produce effects on multilane roads that are similar to those produced by the PHB alone.

The Gateway treatment offers several advantages over the PHB. First, the Gateway treatment is less expensive than the PHB. Second, it does not require special outreach efforts to educate the public on how to respond to it. Third, it does not require a push button or pedestrian detector to activate, which makes it effective during all crossings.

However, two disadvantages of the in-street sign were noted. First, it cannot be left in place during the winter at locations that receive snowfall that requires plowing, and second, the sign needs to be replaced if repeatedly struck by vehicles (this did not occur in our study). The in-street sign is an impactable sign that is designed to be struck. However, in-street signs are subject to damage when repeatedly struck, the replacement of these signs could still be more cost effective than installing a PHB because of their low cost. Further research is needed to determine the durability of the Gateway treatment. Vehicles may be less likely to strike in-street signs that are placed at the edge of the roadway. The signs on the lane line are most vulnerable and may limit the application of this device on higher speed roads.

Another application for the Gateway treatment could be at crosswalks at intersections with corner turning islands. If the slip lane is a single lane, signs could be placed on the each side of the lane. A similar application could be tested at crosswalks at freeway off ramp locations.

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Date: May 12, 2011

To: Ron Van Houten, Principal Investigator
Hana Manal, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 11-05-13

This letter will serve as confirmation that your research project titled "Evaluating Pedestrian Safety Improvements" has been **approved** under the **exempt** category of review by the Human Subjects Institutional Review Board. *The waiver of informed consent meets the provisions set forth in 45 CFR 46.116 of the Code of Federal Regulations and is granted.* The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: May 12, 2012

