8-2018

The Effects of Gateway Width on Driver Yielding to Pedestrians: A Systematic and Parametric Analysis

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THE EFFECTS OF GATEWAY WIDTH ON DRIVER YIELDING TO PEDESTRIANS: A SYSTEMATIC AND PARAMETRIC ANALYSIS

by

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A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Master of Arts
Psychology
Western Michigan University
August 2018

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The gateway in-street sign treatment has been demonstrated to be a cost-effective method for increasing driver yielding behavior at crosswalks. In the present study, wide and narrow gateway widths were compared at two sites to determine if there was a differential effect on driver yielding behavior. Then, the relationship between width and yielding was refined with a parametric analysis at one of these sites. Gateway width was varied in two-foot intervals from 12ft to 18ft. The results indicated an inverse relationship between gateway width and driver yielding behavior. There are likely two variables related to this effect. First, because drivers need to navigate between the two signs it is highly likely they need to read the signs (a timely prompt to yield) before traversing the crosswalk, and attending to the sign is likely most probable when the gap is narrow. Second, it has also been determined that there is an inverse relationship between vehicle speed and driver yielding behavior. One reason for this effect may be related to the decreased effort required to brake when traveling at a lower speed than when traveling at a higher speed. Future research should examine whether gap width is inversely related to vehicle speed.

ACKNOWLEDGMENTS

I would like to begin by thanking Dr. Ron Van Houten for his tutelage over the last several years and the expert advice he provided while designing this study, as well as preparing the manuscript. His enthusiasm for research and applying that research to benefit society are an inspiration to myself and many others. I would also like to thank the members of my committee, Dr. Heather McGee and Dr. Alan Poling, for taking the time to review this work and providing their invaluable feedback. Finally, I would like to thank my parents, Mark and Dorothy, for their unending support.

Jonathan M. Hochmuth

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Introduction

Everyone is a pedestrian at some time or another; no matter how long or often one drives, every trip to work, the bank, or the grocery store begins, and ends, as a pedestrian. According to the National Highway Traffic Safety Administration (2017), in 2015 there were 5,376 pedestrian fatalities and 70,000 more pedestrians injured in accidents with a motor vehicle. In 2016, the number of fatalities rose to 5,987; a 9% increase (National Highway Traffic Safety Administration [NHTSA], 2018). Since 2004, there has been a steady decrease in the number of pedestrian fatalities from year to year; however pedestrian fatalities over the last few years are the highest they have been in a decade. Moreover, as a proportion of total traffic fatalities, pedestrian fatalities have risen from 11% to 14% during this period (NHTSA, 2017).

As Bennett and Van Houten (2015) pointed out, the engineering of roads to increase pedestrian safety dates to ancient Rome where raised crosswalks with gaps in them for the cart wheels forced cart drivers to slow. Since that time, traffic engineers have utilized a variety of interventions to increase safety for pedestrians. One traffic engineering intervention which has been demonstrated to be effective is a sign designed for in-street use, called the R1-6 in the *Manual for Uniform Traffic Control Devices*, which reads "STATE LAW YIELD TO PEDESTRIANS," (Federal Highway Administration [FHWA], 2009).

Previously, the effects of the R1-6 in-street sign had been examined when it was placed on the yellow centerline of a two-lane road, producing an average of 84% yielding in one lane and 67% in the other lane (Kannel, Souleyrette, & Tenges, 2003). Ellis, Van Houten, and Kim (2007) investigated centerline placements of the R1-6 sign at the crosswalk, compared to placements at 20 ft and 40 ft, finding that all three conditions produced significant improvements in yielding over baseline. When the authors put signs at all three distances simultaneously, they saw no substantial increase over the crosswalk placement (Ellis et al., 2007). Both Kannel et al. (2003) and Ellis et al. (2007) found that the R1-6 sign, when placed on the yellow centerline, was struck frequently by vehicles, and the latter recommended that when possible they be placed on a raised median island instead. Turner, Fitzpatrick, Brewer, and Park (2006), assessed the use of the in-street sign at 14 locations and found an average of 87% yielding across all sites. However, they noted that the number of sites with more than two lanes (i.e., multi-lane) was limited, and the multi-lane sites that were included in the study exhibited yielding as low as 30% even with the R1-6 in-street sign.

However, Bennett, Manal, and Van Houten (2014) investigated a novel configuration of the in-street sign, called a gateway. In the gateway configuration, an R1-6 sign is placed in each gutter pan (i.e., the flat, concrete portion adjacent to the base of the curb), or on the lane line marking the edge of the road where applicable, and on each subsequent lane line in the road, including the centerline. This requires a vehicle to pass between two R1-6 signs flanking their travel lane when traversing a pedestrian crosswalk. The authors assessed these configurations at two locations. At one location, they found that yielding increased from a baseline average of 25%, to 56% in the centerline only condition, and 79% in the gateway condition. They found similar results at a second location, with average yielding in baseline of 23%, increasing to 45% in the centerline only configuration, and 82% in the gateway configuration (Bennett, Manal, & Van Houten, 2014).

Bennett and colleagues (2014) also examined the effects of the R1-6 sign in comparison to, and in conjunction with, two different pedestrian-activated countermeasures. One of these was a pedestrian hybrid beacon (PHB) which is suspended over the crosswalk on a mast arm or span wire, consists of a single yellow and two red lights, and presents a yellow to red lighting sequence that signals motorists to yield. The other was a rectangular rapid flashing beacon (RRFB), which are post-mounted on both sides of a crosswalk, and presents an irregular flashing pattern of LED lights. The PHB and R1-6 signs were compared at two locations and the authors found average yielding of 1% and 10% in baseline (i.e., no sign or beacon), 62% and 85% in the PHB alone condition, and 85% and 94.5% in the PHB plus centerline R1-6 sign condition, respectively. At one of the sites, the gateway configuration was examined without the PHB being activated, and the authors found an average yielding of 72%. They also assessed a single location with the RRFB, and found baseline yielding levels (without the RRFB activated) of 20%, 69% in the RRFB alone condition, 80% in the gateway R1-6 sign alone configuration, and 85% in the RRFB plus gateway R1-6 sign condition. The authors concluded that the gateway configuration produced greater levels of yielding than a single sign, that it produces comparable levels of yielding to much more expensive interventions, and that it can improve the effectiveness of those interventions when used in concert (Bennett et al., 2014).

Bennett and Van Houten (2015) examined several additional factors involving the R1-6 sign; assessing the influence of the sign symbol and message, replacing some of the R1-6 signs in the gateway configuration with fluorescent, durable, polyurethane, traffic delineator posts, and comparing the gateway configuration to alternatives which used fewer in-street signs. The authors found average baseline yielding of 7% at two sites, which increased to 79% and 77% in the gateway R1-6 sign condition, respectively. They also measured the effects of the sign placed only on the edge of the road, or on the centerline only, and compared yielding under those conditions to the gateway at two of these locations. Edge sign placement alone produced an average yielding of 36% and 10%, while centerline sign placement alone produced 52% and 18%, respectively. When the R1-6 signs were switched with identical, yellow-green blank signs, which had no symbols or messages, in the same configuration, average yielding fell to 27% and 39%. When the authors replaced the most vulnerable signs in the gateway configuration (i.e., those in the roadway, unprotected by the curb), with fluorescent traffic posts, they saw a slight decrement in average yielding compared to a gateway which used only R1-6 signs. At both locations, Bennett and Van Houten found that in this gateway with delineator condition, average yielding was 60%. At a third location they found average baseline yielding was 0%, which increased to 59% in the gateway with traffic post condition, and to 89% in the gateway with all R1-6 signs condition. Bennett and Van Houten (2015) concluded that it was not simply the presence of the sign in the road which produced the increase in yielding, but that the message on the sign was also important, given that the blank signs produced little benefit in yielding. However, they also demonstrated that the placement of the signs in the road is a "critical factor" in the efficacy of an in-street sign configuration, and the center vs. edge sign comparison suggested that the distance between signs might be a variable of interest. Additionally, they raised the question of durability of a gateway installation and began to address it by examining the effects of replacing certain elements of a gateway with more durable components (Bennett & Van Houten, 2015).

In terms of sign durability, a longitudinal study (August to October 2015, and May to November 2016) that examined the cost and survivability of various elements of the gateway configuration determined that certain types of sign mounts were more vulnerable than others, regardless of their position in the road (Van Houten, Hochmuth, Dixon, & McQuiston, 2018). However, even less durable sign-mount units were capable of surviving when placed on top of a curb. When signs were destroyed, and the gateway treatment remained only partially intact, yielding did decrease at these sites, though not to baseline levels (Van Houten et al., 2018). The more frequently signs are the destroyed or damaged, the more frequently they must be replaced, and the more expensive the treatment becomes. That said, mounting a sign on a curb necessarily increases the width of the gap between signs, because the top of the curb is often as much as 2 ft removed from the edge lane line, or further yet if there is a dedicated bicycle lane. Thus, the relationship of driver yielding to the distance between signs in a gateway configuration is an important variable to investigate when balancing sign survival, cost, and efficacy. In addition to the issue of sign survival, the same study also discovered that the gateway configuration reduced motorist speeds by an average of 5mph at the crosswalk even when no pedestrian was present, which has important implications for reducing pedestrian fatalities on its own (Van Houten et al., 2018).

In the present study we examined the effects of wide and narrow gateway configurations of the in-street sign on drivers yielding the right of way to pedestrians at two locations. The variable of width between signs has practical implications for survivability of permanent installations and begins to explore the effect of "perceived narrowing" hypothesized by Bennett et al. (2014).

Method

Settings

Two sites were assessed in Portage, Michigan. Oakland Drive was a midblock trail crossing, with a pedestrian island (Figure 1). The site featured two-way traffic (north-south) with one lane on each side of the pedestrian island; each lane included a dedicated bicycle lane. The total width of each of the lanes was 18.75ft including the bike lane; the southbound lane had a 6.5ft wide bicycle lane and the northbound lane a 5.5 ft wide bicycle lane. Average Daily Traffic (ADT) at this location was 18,111 (Traffic Count Database System, 2018) and the posted speed limit was 35 mph, though it appeared that vehicles at this site regularly exceeded that. A permanently blinking yellow light mounted on top of a sign indicating the upcoming crosswalk was located on the edge of the southbound lane, 460 ft in advance of the crosswalk. This location also featured a blinking yellow light which could be activated by a button press, which was located on a trail-crossing sign, suspended above the roadway on a mast arm. This device was inoperative when the experiment began, but the city repaired it upon our request, and it was later incorporated into the design.

Figure 1. Oakland Drive location with pedestrian-activated light.

The second site was Garden Lane, a midblock trail crossing, with two-way traffic (east-west), one lane in each direction (Figure 2). The westbound lane was 16.75 ft wide at the crosswalk; the eastbound lane was 20 ft wide at the crosswalk, and had a substantially wider paved shoulder compared to the westbound lane. The ADT at this location was 2,734 (Traffic

Count Database System, 2018) and the posted speed limit was 30 mph. This site was located at the middle of a large park that has a high volume of foot and bicycle traffic.

Figure 2. Garden Lane location, facing East.

Participants

Participants included any motorist passing through the crosswalk when a pedestrian was present at the locations listed during data collection periods. All behavior recorded was publicly observable and no identifying information was collected at any time.

Apparatus

The device used in this study was the R1-6 in-street sign, which consists of a yellow-green, reflective plaque, with a message instructing drivers to yield to pedestrians with a combination of symbols and words (FHWA, 2009). The signs used in the present study were 36 in high by 12 in wide, with an inset white background 23.75 in high by 9.5 in wide. The yield symbol was 7.5 in high by 8 in wide, and the pedestrian figure was 8 in high. The lettering was 1.5 in high. During experimental manipulations of the configurations, these devices were mounted on temporary, portable bases rather than permanently affixed to the road surface.

Dependent Variables

We measured the number of motorists who did and did not yield to pedestrians in crosswalks in the same manner as described by Bennett et al. (2014). Driver yielding was measured in reference to an objective dilemma zone (DZ), a location beyond which a driver can easily yield if a pedestrian enters the crosswalk. We utilized the formula used to determine whether a driver could have safely stopped at a traffic signal to determine whether the driver could have stopped for a pedestrian standing with one foot in the crosswalk: $y = t + (v/2a+2Gg)$ (Institute of Transportation Engineers, 1989). This formula accounts for driver reaction time, safe deceleration rate, the posted speed, and the grade of the road to calculate this interval for the yellow traffic light. This formula was used to determine the distance to the dilemma zone boundary by multiplying the time (y) by the posted speed limit in feet per second: where t = the perception and reaction time in seconds (1 s); v = the speed of approaching vehicles in feet per second (we substitute the posted speed limit in feet per second); a = the deceleration rate, recommended at 10ft/s^2 ; G = acceleration due to gravity (32ft/s^2); and g = the grade of the approach. The location of the DZ was marked by either a lawn flag located adjacent to the road, or with colored duct tape that extended from the top of the curb into the gutter pan. At Oakland this resulted in a DZ of 183 ft and at Garden Lane a DZ of 141 ft.

Motorists who had not passed the outer boundary of the DZ 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 placed a foot in the crosswalk could be scored as yielding but could not be scored as failing to yield because the motorist was not legally required to yield at this distance. However, the signal timing formula is relatively lenient; hence, and many vehicles that passed the DZ could have yielded safely, particularly those traveling below the speed limit.

Procedures

Researchers were trained to use the operational definition of yielding behavior. They practiced recording together until they obtained inter-observer agreement of 90% or better for two consecutive sessions (a total of 40 observations). Researchers were also trained on how to use a walking wheel to measure the distance to the DZ, and how to place the small lawn flags or lay the tape to delineate the DZ.

The researchers set up the DZ before beginning trials. A walking wheel was used to measure the distance from the nearest crosswalk line to the DZ. 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 yellow-green, reflective vests during the marking process to make themselves more visible to drivers. The researchers then marked the location with the necessary flags or tape.

Only drivers in the first travel lane were scored for yielding after the pedestrian had entered the crosswalk. This procedure was used because it conforms to the obligations of motorists specified in most motor vehicle statutes regarding who has the right of way at what time. At Oakland Drive, motorists in the second lane of the roadway were scored as a separate trial, because there was a median island (i.e., a raised section of sidewalk or pavement) separating the travel way, however, if no vehicles were in the second lane the crossing was completed and that portion was not considered a trial. At Garden Lane, where there was no median island, drivers in the second lane of the road were scored when the pedestrian had entered the second half of the first lane preceding the yellow centerline, if they were beyond the DZ for that travel lane, and were scored in the same trial as the crossing for the first lane.

Each session consisted of 20 trials (pedestrian crossings). A trial, or staged crossing, began when a researcher placed one foot within the crosswalk with their head turned in the direction of the approaching vehicle, and ended when that researcher safely stepped out of the street. A research assistant recorded the results of the trial on the data sheet immediately following the cessation of each trial.

The percentage of drivers who yielded the right of way to pedestrians was calculated for each session by dividing the number of drivers that yielded the right of way during that session by the number of drivers that yielded plus the number of drivers that failed to yield during that session. Data were collected during daylight hours between April 2014 and August 2015, and no data were collected when it was raining.

Inter-observer agreement was calculated for both experiments, and data were collected during each condition of each 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. Inter-observer agreement was calculated within each session by dividing the number of agreements by the number of agreements, plus the number of disagreements. The result of this calculation was then converted to a percentage. At the beginning of inter-observer agreement sessions, one observer was designated as the primary observer; it was this observer’s final yielding percentage which is represented in the data set.

During sessions in which inter-observer agreement data were collected, each observer stood several meters apart at a location with an unobstructed view of the crosswalk. They then independently recorded motorist yielding behavior and did not discuss with each other how they scored any of the trials. This procedure controlled for potential observer bias.

Experiment 1

Two different configurations of the gateway were assessed at each location (wide and narrow), and compared to baseline levels of yielding. At Oakland Drive, the wide configuration consisted of an R1-6 sign placed on the left side, in the gutter pan adjacent to the pedestrian island, and second R1-6 sign was placed on the right side in the gutter pan. The narrow gateway configuration involved an R1-6 sign placed on the left side, in the gutter pan adjacent to the pedestrian island, and a second R1-6 sign was placed on the right side, on the bicycle lane line. These configurations were also tested in conjunction with the flashing beacon at Oakland Drive. At Garden Lane, the wide configuration consisted of an R1-6 sign on the yellow centerline, with another R1-6 on the shoulder of the road, where the pavement met the grass. The narrow configuration at this location maintained the centerline placement, and moved the signs on the edges of the road to the white, edge lane line. The resultant distances between signs on either side of a given lane (i.e., the amount of narrowing) in each condition can be found in Table 1. In each case, the particulars of these sign configurations were dictated by the existing characteristics of the sites in terms of sign placement and the resulting widths between the signs. These configurations can be seen at each site in Figure 3.

Figure 3. Oakland Drive trail crossing wide (top left) and narrow (top right) configurations; Garden Avenue trail crossing wide (middle left) and narrow (middle right) configurations.

Results

The percentage of driver yielding right of way to pedestrians in the crosswalk under each condition at the Oakland trail crossing can be seen in Figure 4. Baseline yielding at this location averaged 2.7%, while the wide configuration of the R1-6 sign increased average yielding to 10.0%. However, the narrow configuration produced average yielding of 39.1%. After the city repaired the pedestrian-activated blinking beacon over the roadway, we examined the effects of the beacon in isolation (baseline with light). The blinking light alone resulted in an average of 2.4% yielding, which was very similar to baseline yielding without the light. When we combined the light with the R1-6 sign, the narrow configuration produced an increase in average yielding to 56.9%. However, a full replication of that condition was not possible due to complaints made about the narrow configuration to law enforcement, despite having permission to experiment at the location. To prevent any further conflicts, the signs were then moved to the wide condition and with the addition of the light produced an average yielding of 22.5%.

The percentage of driver yielding under each condition at the Garden trail crossing can be seen in Figure 5. Baseline yielding at this location averaged 19.6%, while the wide gateway configuration of the R1-6 sign produced an increase in average yielding to 66.6%, and the narrow configuration an average of 75.3%. However, at this location both wide and narrow configurations resulted in comparable levels of yielding, with a great deal of overlap in the data paths.

Inter-observer agreement on the percentage of drivers yielding to pedestrians was calculated for 28% of all observations, and averaged 97.6% across both sites, with a range of 90% to 100%.

Across all locations, gateway configurations produced an increase in yielding over baseline, and this increase was often substantial, though the effect may be moderated by several factors, such as speed and density of traffic. Additionally, the narrow configuration produced comparable or greater levels of average yielding relative to wide configurations. An average narrowing of 5.6 ft using the R1-6 sign was sufficient to produce these changes in yielding behavior (Tables 1 & 2).

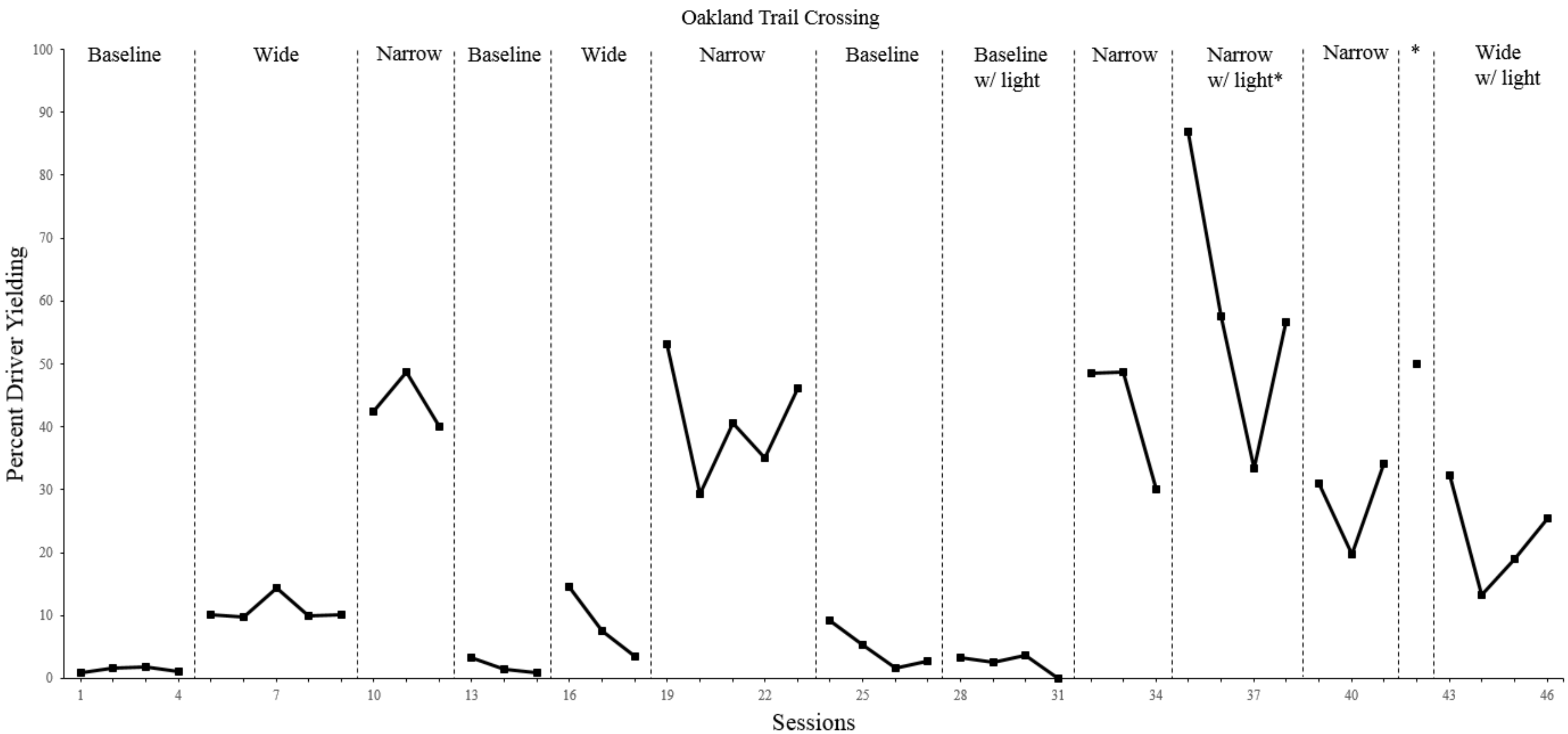

Figure 4. Percent driver yielding in wide vs. narrow gateway configurations at Oakland Drive.

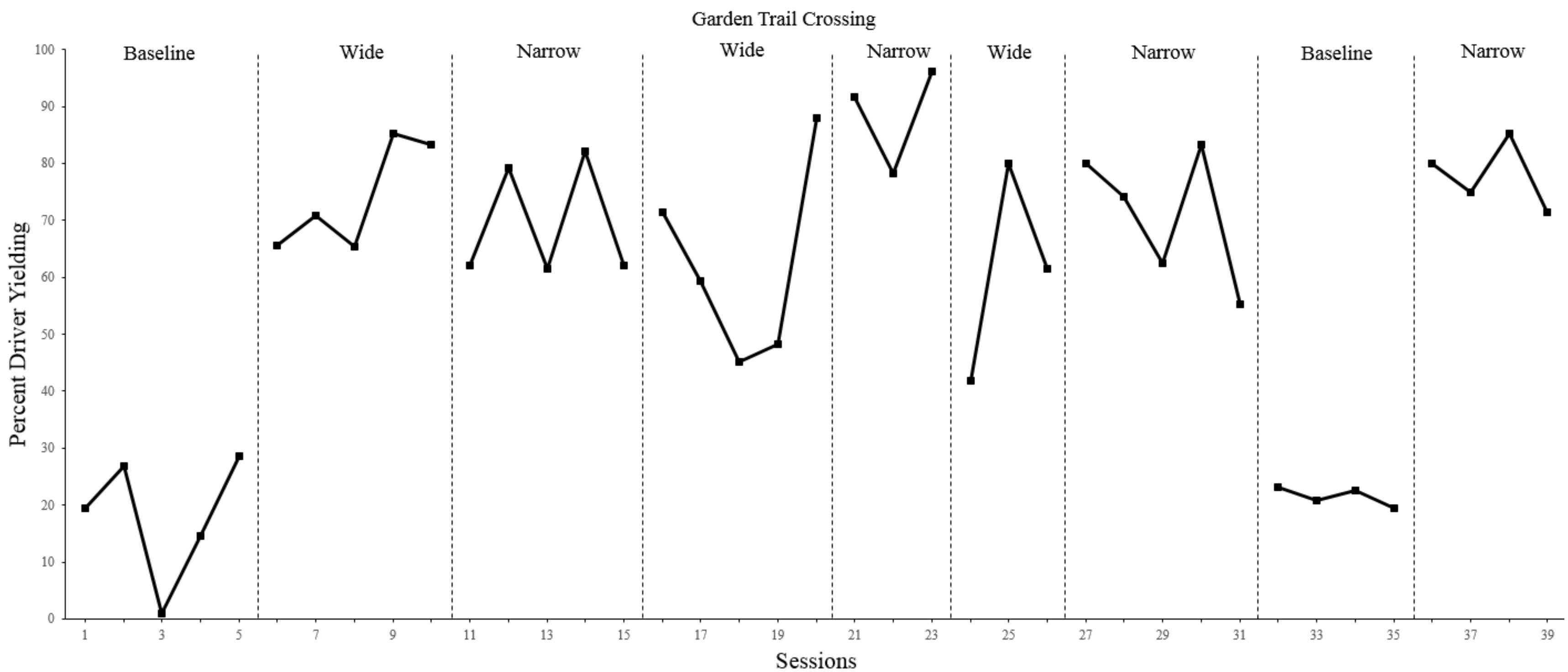

Figure 5. Percent driver yielding in wide vs. narrow gateway configurations at Garden Avenue.

Table 1

Distance Between Signs in Feet on Either Side of Lane by Location and Lane

	Configuration	
Location	Wide	Narrow
Oakland N. Bound	17.25	12.50
Oakland S. Bound	18.00	11.75
Garden E. Bound	20.75	19.25
Garden W. Bound	19.25	16.00

Table 2

Average Yielding by Configuration and Location

	Configuration					
	Baseline		Wide		Narrow	
Location	Mean	SD	Mean	SD	Mean	SD
Oakland	2.73	2.51	9.97	3.55	39.10	9.58
Garden	19.59	8.12	66.59	15.26	75.28	11.47

Experiment 2

The second experiment was conducted at the Garden Lane location and the same general procedures described for Experiment 1 were used in Experiment 2, except that four separate gateway widths were marked using colored duct tape, in 2 ft intervals, ranging from 12 ft to 18 ft. The outer edge sign was then systematically adjusted to produce each gateway width, and the effect on yielding measured. Originally, a reversal design was planned, beginning with 16 ft and descending to 10 ft gateway width, followed by a counterbalanced sequence of conditions. However, the first author became concerned with the possibility of a sign being struck at the planned lowest increment, and instead the signs were moved to 18 ft in order to maintain the parametric nature of the study. Rather than a classic reversal, the "reversal" phase utilized an alternating treatments design, with the order of conditions counterbalanced by time of day using a Latin-Square generator, ensuring that all combinations of gateway width and time of day were equally represented.

The width of the gap between the edges of the R1-6 signs in the gateway configuration was systematically varied in 2ft increments, resulting in a 12 ft, 14 ft, 16 ft, and 18 ft distance between the edges of the signs. The difference between the narrowest (12 ft) and widest (18 ft) gap equaled 6 ft, which was similar to the average gap width of 5.6 ft found to be effective in Experiment 1. The four conditions can be seen in Figure 6.

Figure 6. Gateway widths at Garden Avenue 12 ft (top left), 14 ft (top right), 16 ft (bottom left), and 18 ft (bottom right).

Results

A clear, inverse relationship between gateway gap width and percentage of driver yielding can be seen in Figure 7. The change in average yielding between the widest gap (18 ft) and the narrowest gap (12 ft) was 13%, and all treatment conditions produced a substantial increase in yielding over baseline, as seen in Table 3. The individual session data with phase averages and the alternating treatments "reversal" phase unpacked for clarity, given the overlap in the data paths, can be seen in Figure 8. Inter-observer agreement was calculated on over 40% of trials, with an average of 97.3%, and a range of 92.5% to 100%.

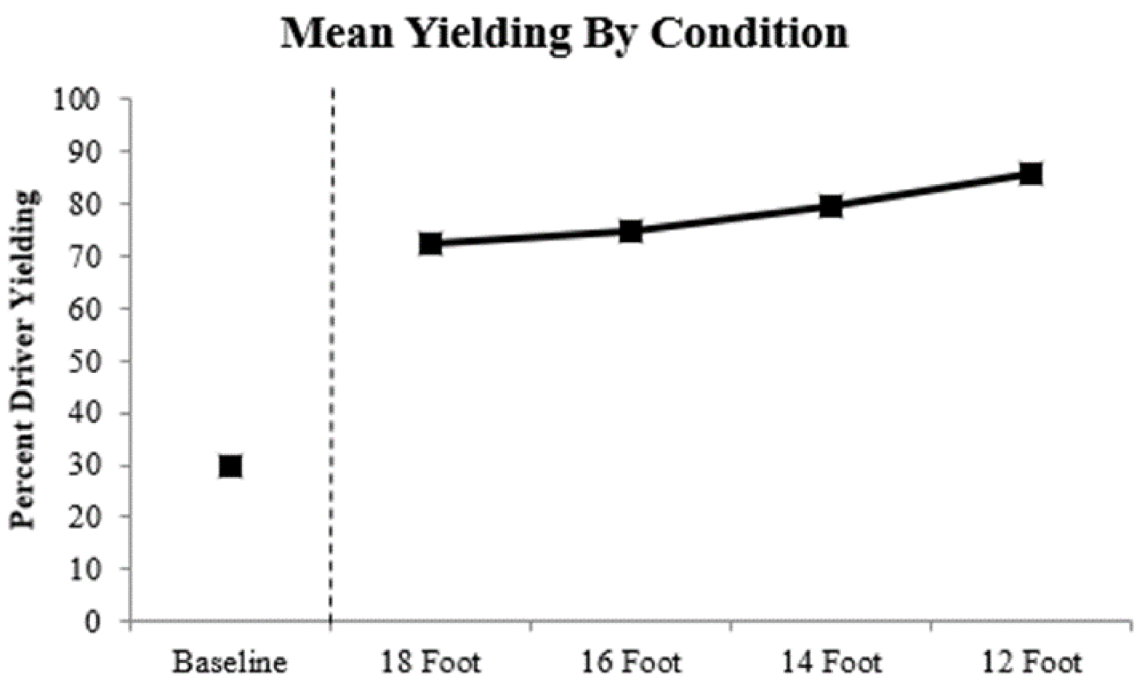

Figure 7. Average driver yielding by condition at Garden Avenue trail crossing.

Table 3

Average Yielding by Condition in Parametric Analysis

	Yielding	
Condition	Mean	SD
Baseline	29.63	5.72
18ft	72.58	7.40
16ft	74.87	10.46
14ft	79.50	6.32
12ft	85.83	7.24

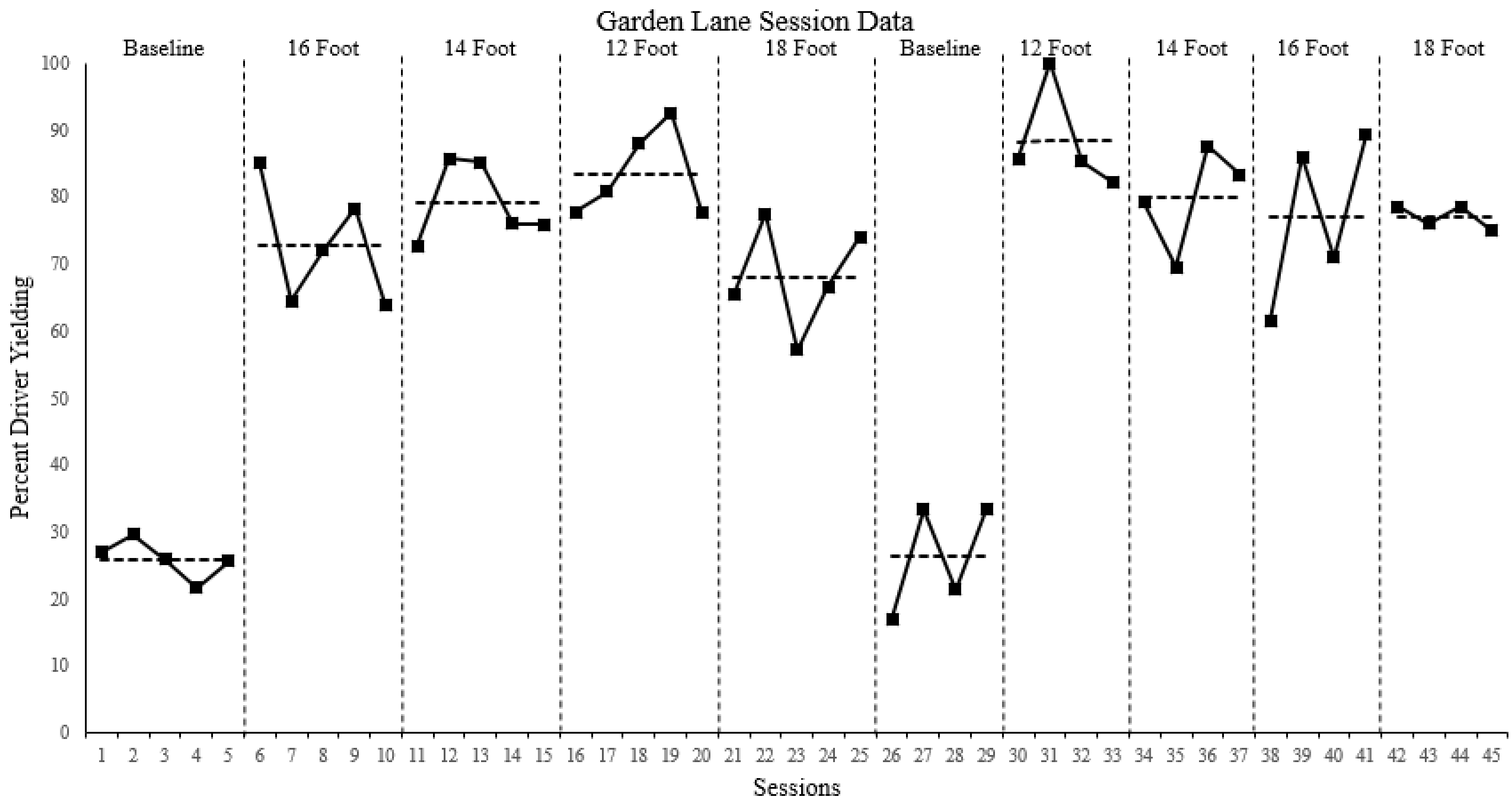

Figure 8. Percent driver yielding at Garden Lane by session with phase average.

Discussion

The results of the present study, and those which have preceded it, demonstrate that in regard to the R1-6 sign the use of a gateway configuration at any width has the greatest effect on yielding. That said, the width of gap for in-street sign gateways does influence the degree of driver yielding to pedestrians, however the gain in yielding may not outweigh the possible reduction in survivability of the signs at a given location. This factor should be considered not only because of cost, but also because damage to the signs may result in a further reduction in yielding; while damaged sign configurations do not always fall to baseline levels, their performance is lower than an undamaged gateway (Van Houten, & Hochmuth, 2016). While the present study examined a range of gap widths between signs in the gateway configuration, future research should determine whether smaller changes, such as those between a lane line and curb top, produce significant changes in yielding. If not, where possible, curb top placements may be more valuable as a matter of practicality, as in addition to being more survivable, they also do not interfere with snow-removal or water-drainage.

Bennett et al. (2014) hypothesized that the increased yielding may be a result of the boundaries of the lanes being made more salient, by extending those boundaries vertically, and suggested that the gateway configuration should cause motorist speeds to decrease. Bennett et al. (2014) were unable to collect these data; however, some preliminary data reported by Van Houten et al. (2018) indicate significant reductions in speed at the crosswalk in the absence of a pedestrian. This effect needs to be replicated to determine its generality, and more data are being collected currently on the passive effects (i.e., traffic calming) of the gateway on motorist speeds. However, the apparent effect of the gateway on speed is particularly important because as vehicle speed increases, so does the likelihood of a pedestrian fatality. According to a report prepared for the Australian Department of Transport (McLean, Anderson, Farmer, Lee, & Brooks, 1994), the probability of a pedestrian fatality when struck by a vehicle at 20 mph is 5%, but that probability rapidly increases to 37% at 30 mph, and 83% at 40 mph. If the hypothesis of Bennett et al. (2014) holds, then the increase in yielding obtained with narrower configurations demonstrated in this study suggests that slower speeds should also be obtained. As such, the differential effects of narrow and wide gateways on speed should be assessed. Furthermore, in the vein of Bennett and Van Houten (2015), this effect should also be examined with yellow-green sign blanks in the same configurations. The latter would help to determine whether the verbiage on the signs which resulted in substantially higher yielding (Bennett, & Van Houten, 2015) is also contributing similarly to speed reduction.

It may be that the increased yielding seen in the gateway condition is in part a product of decreased response-effort for the motorist. For instance, slowing to avoid striking the signs and damaging one’s car, may result in the motorist’s foot already being over the brake, and coupled with the reduced speed this may result in reduced effort to yield at the sight of a pedestrian. The presence of the signs may also evoke “scanning” (i.e., looking back and forth) behavior by the motorist, which may increase the likelihood that they see a pedestrian standing at the crosswalk, and subsequently yield to them. Finally, it is interesting to consider that the light at Oakland Drive which was ineffective on its own, may have facilitated the effectiveness of both the narrow and wide configurations of the gateway. Unfortunately, a full replication of that condition was not possible due to unforeseen circumstances. However, it might be beneficial for future research to examine the use of multiple low-cost interventions which are insufficient on their own to produce the desired level of yielding at a site like Oakland Drive, to determine what would be necessary to attain that level of yielding.

While there is more to learn about how to optimize the effectiveness of the gateway configuration, as well as why they work as they do, enough is known to begin installing gateways at the state and local level. Wide-scale implementation and time will allow us to determine if the gateway treatment is associated with a crash modification factor (CMF). A CMF is a multiplier which estimates the expected number of crashes if a particular countermeasure is used. For instance, if a location has 100 crashes per year of a certain type, implementing a countermeasure with a CMF of 0.7 would estimate 70 crashes, while a CMF of greater than 1.0 would predict an increase in crashes of that type. The outlook for such research is promising, as the gateway configuration produces comparable levels of yielding to more expensive treatments (i.e. the rectangular rapid-flashing beacon) (Bennett et al., 2014), and reductions in speed which both are associated with a CMF (Zegeer et al., 2017).

Another limitation of the present study is that it only assessed two locations, and the ADTs at those locations were highly disparate. Previous research has shown that both speed and ADT (i.e., traffic density) may attenuate the effects of high-visibility prompts, such as the R1-6 sign (Turner, Fitzpatrick, Brewer, & Park, 2006; Van Houten, & Hochmuth, 2016). Future research should focus on examining a broader range of site characteristics to determine the extent to which these variables influence the efficacy of the in-street sign gateway configuration. Conveniently, the same kinds of studies which would facilitate the calculation of a CMF could assist in addressing this limitation.

Perhaps the most difficult limitation of the present study, and research like it, is that many of the controlling variables are unknown and uncontrollable. A given motorist has their own idiosyncratic history of experiences, and equally individual environmental factors acting on them when they pass through an experimental location. Furthermore, without providing any structured consequences, the only consequences they experience will be relative to their histories and current context. Moreover, many of the sites where this research is conducted have pre-existing features designed to control behavior (e.g., width of the road, signage, road markings, etc.) all of which becomes a part of the milieu being measured in baseline; the experimental "levers" available to us are often limited. This limitation, however, is also a demonstration of the relative power of treatments like the R1-6 gateway. A simple set of signs, deployed in the appropriate way, is often able to influence behavior despite those idiosyncrasies in the thousands of motorists being observed, and produce high rates of yielding.

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