Effect of Advance Yield Markings and Symbolic Signs on Vehicle-Pedestrian Conflicts: A Field Evaluation

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ABSTRACT

The Commonwealth of Massachusetts has made walkable communities a priority. Pedestrian safety is a key to the success of this objective. Pedestrians are at especially high risk when traversing unsignalized, marked crosswalks located either midblock or at T-intersections, especially when a vehicle adjacent to the driver is blocking his or her view of a crossing pedestrian. A number of treatments have been proposed as ways to reduce crashes at such crosswalks in such situations. Two such experiments were conducted in the town of Greenfield, MA, to assess the effectiveness of advance yield markings on drivers’ scanning for pedestrians and to study their yielding behavior. Advance yield markings consist of a line of white triangles twenty to fifty feet in advance of the crosswalk together with a sign indicating that drivers should yield at the markings. The first experiment was an observational one involving a staged pedestrian attempting to use the crosswalk while the second experiment was an in-vehicle field study conducted on an open road course in Greenfield, MA. Results demonstrated that advance yield markings, coupled with the vacating of parking spots immediately adjacent to the crosswalk to clear the line of sight of approaching vehicles to pedestrians entering the crosswalk, improved yielding compliance. In addition, when advance yield markings and warning signs were present, drivers approaching the crosswalk were more likely to scan areas to the sides of the roadway at crosswalks in anticipation of a pedestrian entering the crosswalk.
INTRODUCTION

According to the U.S. Department of Transportation, in 2009 there were 4,092 pedestrian deaths that accounted for 12% of all traffic related fatalities in the United States. Of these, nearly three out of four were in urban areas. Seventy-two percent of all pedestrian deaths occur at non-intersections. Contrary to popular belief, nearly 90% of pedestrian fatalities occur during normal weather conditions, as opposed to rain, fog or snow. Nearly 70% of all fatalities occur at night, and nearly half occur on Friday, Saturday or Sunday. In the Commonwealth of Massachusetts, pedestrian fatalities account for 14.4% of traffic related crashes, which is higher than the national average of 12% (1).

Rather surprisingly, fatal pedestrian-vehicle collisions at marked crosswalks are more likely than at unmarked crosswalks when the locations are uncontrolled, i.e., when the locations do not have stop signs or traffic signals (1). These results were observed on multilane roads with more than one lane in each direction and minimum average daily volumes of 12,000. A major contributor to crashes at unsignalized marked mid-block crosswalks on multilane roads is the presence of a motorist who is yielding to a pedestrian in the crosswalk, creating thereby a possible additional threat from motorists in the adjacent lane who may not see the pedestrian. It is just these conditions which it is argued lead to more multiple-threat crashes at marked than at unmarked mid-block crosswalks (2).

Pedestrian-vehicle crashes represent a clear threat to communities, to the safety of pedestrians, and to efforts which put the community first. Increasing penalties is one way to improve compliance with existing laws. However, it is not the only way to effect an improvement in walkability and safety. Among the most promising treatments for reducing the potential for pedestrian fatalities is the employment of advance yield markings. The goal of this research was to investigate the effects of advance yield markings and signs on drivers’ and pedestrians’ behavior at pedestrian crosswalks, especially those multi-lane situations where the driver’s or pedestrian’s view of critical information is obstructed by one or more vehicles.

Advance yield markings consist of a series of triangular pavement markings placed across the travel lane anywhere from 20 to 50 feet in advance of the crosswalk. A “Yield Here to Pedestrian” sign is placed at the location of the markings. Specifications for the placement and arrangement of such signs can be found in the Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways published in 2009 (3).

Previous studies have shown that the use of advance yield markings and a related “Yield Here to Pedestrian” sign increase drivers’ yielding distance while reducing the number of conflicts at multilane crosswalks with uncontrolled approaches (4,5). In theory, the treatment has the potential to reduce conflicts at multi-threat and sight-limited scenarios. First, the treatment alerts the driver further upstream of the crosswalk to the possibility of pedestrians. Second, it prompts the driver to yield further upstream from the crosswalk increasing the separation between the driver and the pedestrian. Thus, advance yield markings and a related “Yield Here to Pedestrian” sign provide more time for the driver to react and respond. However, it is not known whether these changes might occur solely in scenarios where the pedestrian is visible in the crosswalk. Nor is it known whether the benefit of adding advance yield markings when a vehicle is parked next to the crosswalk is larger than, equal to, or smaller than the benefit that would occur by simply banning parking immediately next to the crosswalk.

Two experiments are reported below. In the Experiment 1, a comparison is made of the effects of advance yield markings and standard markings on yielding and stopping distance behaviors. Also compared in Experiment 1 is the effect of removing one or more vehicles
parked immediately in front of the crosswalk on yielding and stopping distance behaviors. In Experiment 2, a comparison is made of the effects of advance yield markings and standard markings on the likelihood that a driver approaching the crosswalk scans for pedestrians.

**EXPERIMENT 1 – FIELD OBSERVATIONS**

In this experiment, the yielding behavior of real world drivers to a staged pedestrian at four selected crosswalks in Greenfield, Massachusetts was observed. During the staged crossings, videos of each crosswalk were recorded as well as the audio CB-radio communications of the research team as they coordinated the staged pedestrian activity at the crossings. Of primary interest was determining whether advance yield markings resulted in higher yield rates and yield points further back from the crosswalk both when the driver’s view of pedestrians on the side of the road was and was not obstructed.

**Method**

**Crosswalks**

Working closely with town officials and police, four crosswalks in Greenfield, Massachusetts were selected for study. All four crosswalks were within three blocks of the downtown area and had frequent pedestrian crossings. All four contained only the zebra striped crosswalk markings during the initial phase of the experiment and the approaches were later restriped with advance yield markings during the later phase of the experiment. Two of the crosswalks were midblock crosswalks. The other two crosswalks were located at T-intersections. An edited Google Earth screen capture of the studied crosswalks is provided in Figure 1. The locations of crosswalks are labeled and the direction of travel for traffic that was studied at each crosswalk is indicated with a white arrow. The eventual placement of the advance yield markings is indicated in Figure 1.

In order to assess the effectiveness of advance yield markings on driver yielding behavior observations were taken at each crosswalk both before and after advance yield markings were placed referred to, respectively, as the **standard condition** and the **advance condition**.

**Experimental Setup**

Figure 2 describes the general setup for the observational experiment. A large staged vehicle (a rented SUV or pickup truck) was placed in the parallel parking spot immediately adjacent to the crosswalk on the side of approaching traffic in that lane. A high fidelity digital video camera was attached fifteen to twenty feet up the nearest convenient tree or light pole and pointed at the crosswalk. To gauge stopping distance from the video, six inch strips of white tape were placed near the centerline of the road at regular intervals – two feet apart zero to twenty feet from the crosswalk and ten feet apart twenty to sixty feet from the crosswalk. Two screen captures of the field experiment are contained in Figure 3.
FIGURE 1  Crosswalks used in experiment. (A) Main Street (midblock crosswalk); (B) Court Square (midblock crosswalk); (C) Federal & Osgood Sts. (T-intersection crosswalk, branch to right) (D) Federal & Church Sts. (T-intersection crosswalk, branch to left)

FIGURE 2  Generalized crosswalk setup for observational experiment

The research team consisted of four members – three researchers (the spotter, the observer/data recorder and the staged pedestrian) and a safety agent (a police officer). The role of the spotter was to identify vehicles approaching the crosswalk and to signal the staged pedestrian when to approach and enter the crosswalk. The observer/data collector’s job was to record the behavior of the observed vehicle and note whether a proper yield was made. The staged pedestrian’s job was to approach the crosswalk when signaled to do so, take a single step from the curb into the crosswalks, and stop with body language that indicated a desire to cross (one foot forward and attempting to make eye contact with approaching driver).
FIGURE 3: Screen captures from field observation video record. In both cases vehicles have stopped and staged pedestrian is in the crosswalk. Note tape markings on centerline at 2 ft. intervals. Staged vehicles (pickups or minivans) are in marked parking spots immediately adjacent to crosswalk. (A) Federal & Osgood Streets, Standard Condition; (B) Main Street, Advance Condition.

The safety agent was a local police officer hired to prevent local pedestrians not involved in the experiment from walking out into the crosswalk during the experiment.

Procedure

The same procedure was followed at all four crosswalks observed in the experiment. For each observation, the spotter would identify a vehicle approaching the crosswalk by stating its type (sedan, SUV, pickup truck, etc.) and color. The spotter ensured that there was sufficient space between the target vehicle and the car in front of it such that the target vehicle would not be influenced by the actions of any vehicles ahead of it. Once the spotter called out the vehicle over the radio, the staged pedestrian approached the crosswalk and took a single step into the crosswalk and was positioned such that he or she was partially obscured by the staged vehicle parked adjacent to the crosswalk. The observer/data recorder then made notes regarding whether or not the driver yielded to our staged pedestrian and whether a yield was a hard stop. A total of one hundred observations were recorded in such a fashion at each of the four crosswalks in the standard condition. After advance crosswalk markings were painted, a few weeks later another one hundred observations were again taken in the advance condition.

FIGURE 4: Generalized setup and driver line of sight for observations taken with 0, 1, or 2 empty spaces adjacent to crosswalk. As the number of parking spaces adjacent to the
crosswalk is increased, the approaching drivers can see pedestrians entering the crosswalk earlier.

Dependent Variables
In this experiment we define a “yield” as coming to a complete stop for our pedestrian. The dependent variables for this experiment were: 1) whether or not an approaching vehicle yielded (stopped) for our staged pedestrian and 2) for those drivers who did yield, how far back from the crosswalk (estimated from video, in feet) the vehicle stopped. These same dependent variables were recorded for both standard crosswalk and advance yield marking conditions and those conditions in which spaces immediately adjacent to the crosswalk were kept vacant to improve the sightline of approaching drivers.

Results & Discussion
Yielding Behavior
The yielding behavior of observed drivers in this experiment is summarized in Table 1 below. At Court Square (a mid-block crosswalk), 100 observations were taken during the standard condition with zero empty spaces adjacent to crosswalk (see Figure 1. B). In the advance condition, 50 observations were taken with zero empty spaces adjacent and 50 with one empty space adjacent. With zero empty spaces adjacent, there was no significant change in the yielding behavior of approaching drivers. In the standard condition, 26% of drivers yielded to pedestrians as compared to 24% in the advance condition. However, in the advance condition when the space closest to the crosswalk was kept empty, yielding increased to 40% of approaching drivers.

### TABLE 1  Yielding behavior of observed drivers at Greenfield, MA crosswalks in standard and advance conditions

<table>
<thead>
<tr>
<th>Crosswalk Location</th>
<th>Empty Spaces Adjacent*</th>
<th>Total Observations</th>
<th>Total Yields</th>
<th>% Yields</th>
<th>Total Observations</th>
<th>Total Yields</th>
<th>% Yields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Court Square</td>
<td>0</td>
<td>100</td>
<td>26</td>
<td>26.0</td>
<td>50</td>
<td>12</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>50</td>
<td>20</td>
<td>40.0</td>
</tr>
<tr>
<td>Federal &amp; Church</td>
<td>0</td>
<td>99</td>
<td>38</td>
<td>38.4</td>
<td>50</td>
<td>27</td>
<td>54.0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>52</td>
<td>47</td>
<td>90.4</td>
</tr>
<tr>
<td>Federal - Osgood</td>
<td>0</td>
<td>102</td>
<td>18</td>
<td>17.6</td>
<td>49</td>
<td>10</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>50</td>
<td>18</td>
<td>36.0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>50</td>
<td>33</td>
<td>66.0</td>
</tr>
<tr>
<td>Main Street</td>
<td>0</td>
<td>100</td>
<td>3</td>
<td>3.0</td>
<td>52</td>
<td>10</td>
<td>19.2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>50</td>
<td>28</td>
<td>56.0</td>
<td>49</td>
<td>29</td>
<td>59.2</td>
</tr>
</tbody>
</table>

* The number of empty spaces immediately adjacent to crosswalk. "0" = Staged vehicle parked in spot immediately adjacent to crosswalk. "1" = 1 empty space. "2" = 2 empty spaces

At Federal and Church Streets (a T-intersection crosswalk with the branching road to the left of traffic approaching from the north), in the standard condition 99 observations were taken with zero empty spaces adjacent to the crosswalk. In the advance condition, 50 observations were taken with zero empty spaces adjacent and 52 with 1 empty space adjacent. It should be noted that there was a commercial driveway (about the same width as a parking spot) between the crosswalk and the nearest parallel parking spot – thus making the “0 empty spaces” condition in this crosswalk similar to that of the “1 empty space” condition of the other three crosswalks. With zero empty spaces adjacent, yielding increased from 38% in the standard condition to 54% in the advance condition. With one empty space adjacent in the advance condition, yielding behavior of approaching drivers improved markedly to 90%.
At Federal and Osgood Streets (a T-intersection crosswalk with the branching road to the right of traffic approaching from the north), in the standard condition 102 observations were taken with zero empty spaces adjacent to the crosswalk. In the advance condition, 49 observations were taken with zero empty spaces adjacent, 50 observations with one empty space adjacent, and 50 observations with 2 empty spaces adjacent to the crosswalk. With zero empty spaces adjacent, yielding behavior did not change significantly from the standard condition with 18% of vehicles yielding to the advance condition with 20% of vehicles yielding. With one empty space adjacent in the advance condition, yielding behavior increased to 36%. A decision was made in the field to also take 50 observations with 2 spaces empty adjacent to the crosswalk. When this was done, yielding behavior improved to 66% of approaching vehicles.

At Main Street (a mid-block crosswalk), in the standard condition 100 observations were taken with zero empty spaces and 50 with one empty space adjacent to the crosswalk. In the advance condition, 52 observations were taken with zero empty spaces and 49 with one empty space adjacent to the crosswalk. In the standard condition, only 3% of oncoming vehicles yielded to our pedestrian with zero empty spaces whereas 19% yielded in the advance condition. With one empty space, yielding behavior improved markedly in both conditions with 56% yielding in the standard condition and 59% yielding in the advance condition.

**Stopping Location Clearance**

An analysis was also made of the stopping location clearance for yielding vehicles. The clearance distance to the crosswalk was determined by estimating the position of the yielding vehicle’s front bumper relative to the tape lines made on the roadway in the video record. Because of parked cars and lack of a convenient place to put the equipment, laser distance recorders could not be used. As a result, stopping distance had to be estimated from the tick marks placed by our team in the roadway every two feet. The results are summarized in Table 2.

**TABLE 2 Estimated average stopping clearance (ft.) from crosswalk for yielding vehicles in observational experiment**

<table>
<thead>
<tr>
<th>Crosswalk Location</th>
<th>Spaces Adjacent*</th>
<th>Standard Condition</th>
<th>Advance Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Court Square</td>
<td>0</td>
<td>14.7</td>
<td>10.0</td>
</tr>
<tr>
<td>Federal &amp; Church</td>
<td>0</td>
<td>10.9</td>
<td>11.8</td>
</tr>
<tr>
<td>Federal - Osgood</td>
<td>0</td>
<td>16.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Main Street</td>
<td>1</td>
<td>13.0</td>
<td>17.7</td>
</tr>
</tbody>
</table>

With zero spaces empty adjacent to the crosswalk, the presence of the advance yield lines seemed to have little effect on the stopping clearance of the vehicles that did yield, as can be seen in Table 2. In some cases, the average stopping distance actually decreased. The differences in stopping distance were not statistically significant in any comparison between the standard and advance yield condition. However, when parking spaces adjacent to the crosswalk were vacated, the average stopping distance of vehicles increased. However, while both Federal Street conditions approached significance, these increases were not statistically significant. It should be noted that all of these stopping distances are less than the distance the advance yield markings were placed from the crosswalks. In other words, the vast majority of the drivers who did come...
to a complete stop did not stop before the advance yield markings, but instead rolled over them
and stopped somewhere between the advance yield markings and the crosswalk.

Summary of Results

On average, when there were 0 empty spaces, drivers yielded 29.4% of the time when the
advance yield markings were present, but only 21.3% of the time when the standard yield
markings were present. Thus, the advance yield markings lead to an eight percentage point
increase in yielding. The effect of vacating the parking spaces in the advance yield condition was
even more dramatic. Going from 0 empty spaces to 1 empty space led to an increase in yield of
over 27 percentage points. In the one crosswalk scenario where a comparison is possible
between the standard and advance conditions, vacating the parking space immediately in front of
the crosswalk led to a large and almost identical increase in the percentage of drivers yield. In
summary, with respect to yielding, the percentage yielding in the advance condition is always at
least as great as the percentage yielding in the standard condition. But, the effect of going from $n$
to $n+1$ empty parking spaces is greater than the effect of going from the standard to the advance
condition when the number of empty parking spaces is held constant. Thus, if one had the
choice between putting in advance yield markings and keeping the number of empty parking
spaces constant at 0 versus keeping the standard condition and emptying the parking space in
front of the crosswalk, the tentative conclusion based on our results is that the latter action would
lead to a larger increase in the percentage of drivers yielding to pedestrians.

While on average some improvement was recorded with regards to stopping distance in
the advance condition when there were no empty parking spaces, the increase was not
statistically significant. Again, it appeared that the biggest change in stopping distance came
from increasing the number of empty spaces in front of the crosswalk rather than holding the
number of empty spaces constant and installing advance yield markings where standard
markings had been present.

EXPERIMENT 2 – EYE TRACKING STUDY

In this second experiment, the effect of advance yield markings on driver behavior was
investigated. However, in this experiment pedestrian crossings were not staged. Rather, driver
eye behavior was studied as they drove a route that intersected all four of the above-mentioned
crosswalks. This was done by putting a mobile eye tracker on drivers and having them drive in a
driving school vehicle with a licensed driving instructor in the front seat. Of primary interest
was whether or not drivers scanned for pedestrians more often when advance yield markings and
signage were present than when standard yield markings were in place.

Method

Participants

A total of thirty-two drivers from the Greenfield, Massachusetts area were recruited for the
experiment. A driving school based in Greenfield, MA helped with the recruiting process. The
eye behaviors of sixteen drivers were recorded when the crosswalks had standard yield markings
(standard condition). Several weeks later, after the advance yield markings and signage were put
in place, the eye behaviors of a second cohort of sixteen drivers were observed (advance
condition). Sixteen males and sixteen females participated in the experiment. Drivers ranged in
age from 18 to 51 with an average of age of 27.8 and had at least 18 months of driving
experience.
Crosswalks & Experimental Setup

The crosswalks used for this experiment were the same used in Experiment 1 (refer to Figure 1). The experimental set up was similar to that as described in Figure 2. However, since this was an in-vehicle experiment with drivers navigating a route that would intercept all four crosswalks, each of the four crosswalks had to have a staged vehicle and safety officer (in Experiment 1, only one crosswalk was studied at a time). The route (Figure 5) began and terminated at the driving school and approached the crosswalks in the same direction as observed traffic in Experiment 1.

FIGURE 5 Route for in-vehicle experiment. Route direction is indicated by yellow arrows and crosswalks are indicated by number in circles: (1) Court Square, (2) Main Street, (3) Federal & Church Streets, (4) Federal & Osgood Streets.

Procedure

Drivers were randomly assigned to participate in the standard or advance condition. Six to seven drivers were scheduled each day and one driver was run at a time. In order to prevent biasing his or her behavior, the driver was not informed of the true purpose of the experiment – to evaluate how they scan the road at the target crosswalks. They were instead told the experiment was intended to evaluate day-to-day performance of drivers of various ages. Once the informed consent was signed, drivers were taken out to a driving school car which they would use to drive the assigned route.

Once in the car, drivers were instructed to adjust the seat and mirrors to their liking. A licensed driving instructor was present in the passenger seat whose job was to provide the driver with turn-by-turn instructions and to intervene if the driver made a mistake. The driving school car was a mid-size automatic transmission four-door sedan with a passenger side brake pedal installed for the driving instructor. Once situated in the driving school vehicle, the driver was then fitted and calibrated with a mobile eye tracking system. A member of the research team rode along in the back seat to monitor the eye tracking digital recorder during the ride. Once the
eye tracker was calibrated and recording, the driver was instructed to drive the specified route as he or she normally would drive. The route took approximately twenty minutes to complete. No staged pedestrians were used during the experiment. The eye tracking record was instead used to determine whether the driver anticipated the potential presence of a pedestrian entering the crosswalk hidden by the staged vehicle immediately adjacent to the crosswalk. Once the driver finished driving the route and had returned to the driving school, the eye tracker was removed and the driver was invited back into the driving school for debriefing.

**Dependent Variables**

The dependent variable in this experiment was the presence or absence of a glance toward the area from which the pedestrian could emerge from the sidewalk from behind the obscuring staged vehicle.

**Results & Discussion**

**Glances**

The eye tracking record for each driver was analyzed. Of interest was how drivers scanned for potential pedestrians in the crosswalks in both the standard and advance conditions. Two independent reviewers who were not involved with the data collection scored each driver’s video record from their eye tracking scene camera and came to consensus on any trials on which they disagreed. To prevent bias in scoring, reviewers did not know which group drivers were assigned to (standard or advance) nor did they know the age and gender of the drivers. Reviewers determined whether or not drivers made eye glances toward the area from which pedestrians might emerge as the driver approached the crosswalk.

The main hypothesis for this experiment was that the advance yield markings and signage would provide visual cues to the driver that a pedestrian may be in the crosswalk and, as a result, the driver would be more likely to direct eye fixations towards the area from which the pedestrian might emerge from behind the staged vehicle. Eye movements were recorded throughout the drive. However, the videos from the eye tracker tapes were analyzed only from the time the front of the driver’s vehicle crossed the back bumper of the staged vehicle to when the front of the driver’s vehicle intersected the crosswalk.

Results show that, with the exception of the one crosswalk at Federal and Church Streets, drivers did look more often towards the area from which a pedestrian might emerge. Figure 6 contains a summary of the results. At the Court Square crosswalk (mid-block), the percentage of drivers glancing towards the area from which pedestrians might emerge increased from 75% in the standard condition to 86.7% in the advance condition. At the Main Street crosswalk (mid-block), the percent of drivers increased from 56.3% to 81.3%. At the Federal & Osgood Sts. crosswalk (T-intersection), the percent of drivers increased from 68.8% to 81.3%. Only the Federal & Church St. crosswalk (T-intersection) remained the same at 75.0% in both conditions. This may be in part because there was no parking spot immediately adjacent to the crosswalk, so unlike in the other three crosswalks, drivers had a much longer opportunity to glance to check for hidden pedestrians (see Figure 1, panel D, for an example). When excluding the Federal & Church St. crosswalk and only considering the other three, drivers looked more frequently toward the area from which the pedestrian might emerge than in the standard condition, t(30) = 2.061, p < 0.05.

If one only considers those three crosswalks (Court Square, Main Street, Federal & Osgood) where vehicles could be parked immediately adjacent to the crosswalk, then on average
drivers in the advance condition were 25% more likely to glance toward the area in the crosswalk where pedestrians are obscured than in the standard condition (a difference of 16.4 percentage points, 66.7% versus 84.1%).

![Percentage of drivers glancing toward area where pedestrian may emerge from behind staged vehicle immediately adjacent to crosswalk. Pedestrian emerged from the right in all but Court Square crosswalks.](image)

**FIGURE 6** Percentage of drivers glancing toward area where pedestrian may emerge from behind staged vehicle immediately adjacent to crosswalk. Pedestrian emerged from the right in all but Court Square crosswalks.

**Summary of Experiment 2 Results**

In three of the four crosswalks, drivers were more likely to scan to the side toward the area where pedestrians could emerge when advance yield markings were in place than when standard yield markings were there. The only exception was the Federal & Church crosswalk where 75% of the drivers glanced in both conditions. This may be partially due to the fact that at that particular crosswalk, there was a commercial driveway between the crosswalk and the nearest parallel parking spot. Drivers had a much longer opportunity in that case to view pedestrians as they approached the crosswalk. In the other crosswalks, vehicles were parked immediately adjacent to the crosswalk itself, meaning that drivers had a shorter amount of time to view the sidewalk that was obscured by the vehicle.

**SUMMARY & CONCLUSIONS**

In Experiment 1, with the exception of Court Square, the presence of the advance yield markings and additional signage improved the number of drivers who yielded to pedestrians in the crosswalks when vehicles were parked immediately adjacent to the crosswalk. One possible explanation for the lack of an increase at Court Square is the low speed and relatively large width...
of the roadway (one travel lane, with a parking lane on the left and bus lanes on the right). Perhaps approaching drivers felt they could “get around” pedestrians in the crosswalk and drove considerably farther away from the side of the road on which the pedestrian was crossing. Moreover, because of the width of the road, if drivers occupied a position farther away from the pedestrian, the pedestrian could have been visible sooner and about at the same distance for both the standard and advance yield markings. Thus, little would be gained by the advance yield markings.

The results do show that there is a measureable benefit to the advance yield markings and signage when there are no empty spaces. However, including the removal (vacating) of the parking spot closest to the crosswalk provides an even more marked improvement in the yielding behavior of drivers in both the advance and standard conditions. At all four crosswalks, the introduction of advance yield markings and signage by themselves without eliminating any parking spots improved yielding behavior by 8.2 percentage points on average. However, when the nearest parking spot to the crosswalk was vacated, the average improvement across both the advance and standard conditions was 35.1 percentage points. Eliminating two parking spots (at Federal and Osgood Streets) improved yielding by 56.1 percentage points. It is clear that in order to maximize the benefit of advance yield markings, at a minimum the parking spaces between the advanced yield markings and the crosswalk should be eliminated.

In Experiment 2, advance yield markings are more effective than standard yield markings in causing approaching drivers to scan for potentially hidden pedestrians when there are no empty spaces. This result provides an important validation of the simulator results reported in a previous study (6) and only serves to underline the benefit of advance yield markings in the field.

It is clear from the evidence presented that advance yield markings have the potential to reduce crashes and increase glances for pedestrians. Drivers were shown to be more likely to look toward those areas where pedestrians might be obscured by vehicles near the crosswalk after advance yield markings were installed. The data from the field observational experiment demonstrated that removing the parking spot immediately adjacent to the crosswalk led to much higher yield rates for oncoming vehicles in both the standard and advance conditions and, if one had the choice between removing a vehicle in front of the crosswalk and keeping that vehicle, but adding advance yield markings, the larger benefit would come from removing the vehicle. Drivers were much more likely to yield when they had a clearer line of sight, allowing the driver to perceive the presence of the pedestrian and respond accordingly. This was true at both midblock and T-intersection crosswalks.

**ACKNOWLEDGEMENTS**

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