Roundabout Access for Visually Impaired Pedestrians: Evaluation of a Yielding Vehicle Alerting System for Double-Lane Roundabouts

Vaughan W. Inman, PhD.
Science Applications International Corporation
6300 Georgetown Pike
McLean, VA 22101
inmanv@saic.com

Gregory W. Davis, PhD.
Federal Highway Administration, Office of Safety RD&T
6300 Georgetown Pike
McLean, VA 22101
gregory.davis@fhwa.dot.gov

Dona Sauerburger
Certified Orientation and Mobility Specialist
1606 Huntcliff Way
Gambrills, MD 21054
sauerburger@mindspring.com

Two experiments evaluated the feasibility of a pavement treatment to alert blind pedestrians when vehicles have yielded to them at double-lane roundabouts. The first experiment was conducted on a closed course with seven visually impaired individuals. The pavement treatment resulted in significantly more and quicker yield detections than the control condition. However, the number of false positive detections was problematic. The second experiment was conducted at an operating double-lane roundabout with five of the participants from the first study. In the field, the pavement treatment was not effective, probably because the majority of vehicles that yielded did not reach the treated area before stopping. The results were not encouraging for the development of alerting systems at double-lane roundabouts. The challenges to be overcome before an alerting system might be feasible are discussed.

INTRODUCTION

People who are blind may experience difficulty using roundabout crosswalks.[1,2] Recent research has documented this difficulty, at least for the case where traffic volumes are high.[3] The problem, as summarized by the United States Access Board, consists of three parts:

1. Motorists do not yield to pedestrians where the crossing is not signal controlled.
2. Noise from circulating traffic may make aural detection of gaps difficult.
3. Gaps large enough to be aurally detected may be infrequent.

The Americans with Disabilities Act (ADA) requires equal access to transportation facilities. The United States Access Board, which is responsible for developing guidelines for the implementation of the ADA, is currently considering guidelines for providing access at roundabouts.[4] The studies reported here are intended to contribute to an empirical basis for those guidelines.

For the purpose of this study, a gap is defined as any pause in traffic flow in which a pedestrian can cross a roadway without encountering vehicle conflicts. At signalized crossings, visually impaired pedestrians rely on the signals to create gaps, and may use surges in traffic flow to detect the signal phase. However, at uncontrolled crossings, such as at roundabouts, visually impaired pedestrians cannot predict gaps, and must rely on other environmental cues to detect them. For a blind pedestrian to make a safe crossing at a roundabout a gap in traffic must occur, and the pedestrian must be able to recognize when a gap is present and when it is not. Gaps may occur in two ways:

1. No vehicles arrive for a length of time necessary for the pedestrian to cross.
2. Vehicles stop for the pedestrian.

Traffic sounds and other environmental noise can mask the sound of gaps in either circumstance.[3, 5, 6, 7] Both the present studies evaluated a treatment to provide an audible cue that vehicles have stopped. Study One was done on a closed course where the behavior of the vehicles could be controlled. Study Two was conducted at an operating double-lane roundabout.

STUDY ONE

Method

A device was needed to create a distinct sound that pedestrians could use to detect vehicles traveling at the speeds vehicles would be traveling if decelerating at a roundabout crosswalk. To test the concept of a low speed rumble-strip, polyvinyl chloride (PVC) pipe of 3.8 cm (1.5 in) diameter was cut along its length, then secured to the roadway, concave side down, with asphalt tape., Even when driven over at 3 km/hr (1.9 mi/h), the PVC sound strips produced a clacking sound that could be heard over ambient traffic noise, from a distance of about 20 m (66 ft).

Three rows of the sound strips were laid transversely across the roadway. One row was placed on the upstream edge of the crosswalk. A second row was placed 6 m (20 ft) upstream of the first row. A third row was placed 7.3 m (24 ft) upstream of the first row. With this arrangement, a two-axel passenger car that passes over the strips generates a rapid "clack-clack, clack-clack" sound as the two axels pass over the two upstream rows, and then, after a brief delay, another "clack-clack" as the vehicle enters the crosswalk and departs. If the first four clacks are heard, but not the latter two, a stopped vehicle is signified. A pair of clacks that is not preceded by four closely spaced clacks indicates that a previously stopped vehicle has departed.

Study One was conducted on a closed circular road at the Federal Highway Administration Turner-Fairbank Highway Research Center in McLean, VA. The course approximated traffic movement at a double-lane roundabout exit. The control and sound strip treatment conditions were located at different points on the course, separated by approximately 50 m (165 ft).

Four cars were used to simulate traffic. Two loudspeakers were used to broadcast recorded traffic sounds and increase the ambient noise level. The sound level was 68 dbA at the location where participants stood. This sound level approximated that measured during peak traffic at the roundabout used in Study Two.

Participants

Seven individuals with severe visual impairments were recruited from the Washington, DC metropolitan area. All participants reported that they travel independently. Five used a long cane and two were guide dog users. All participants reported that they frequently take walking trips without sighted companions and that at least once per month they take a pedestrian trip to a place they have not visited before. Participants who reported having some vision wore a blindfold during the tests. All participants had hearing within the normal range except for one older male who had bilateral low frequency (500 Hz) hearing loss (-60 db). Participants were paid for participation.

Procedures

The participants were informed that the experiment was to examine accessibility issues at roundabouts, but were told nothing about the sound strip treatment. Before data collection began they were provided an opportunity to explore the mock intersection.

A series of 36 test trials followed 4 practice trials. Scripts governed the behavior of four vehicles on each trial. Top speed was 24 km/h (15 mi/h). The scripts comprised two sets of 18 trials that were repeated at each of the two crosswalks. Three participants were tested in the control condition first, followed by the treatment condition. The remaining four participants were tested in the treatment condition first.

Of the 18 test trials, 8 trials called for a vehicle in the near (right) lane to yield first, 6 called for a vehicle in the far (left) lane to yield first, and 4 trials called for vehicles in each lane to yield at the same time. Throughout the remainder of this document, we refer to the near and far lane rather than right and left lanes respectively, because our focus is from the viewpoint of the visually impaired pedestrian. In both Study One and Study Two, the pedestrian stood on the sidewalk side of an exit lane.

The scripts roughly balanced the lanes that each of the four vehicles used, and the order in which each vehicle passed the crosswalk. The scripts were designed to obscure the number of vehicles, the amount of time between the start of a trial and its completion, and the delay between the first vehicle yield and the second vehicle yield. On two trials in each condition, the first vehicle to yield pulled away after 10 s, so that on those trials, the two lanes were never blocked at the same time. The scripts also directed vehicle speed: normal as vehicles passed the crosswalk. A different randomized order of trials was used for each participant and at each crosswalk.

The participants stood on a platform that simulated a curb and used hand signals to indicate when they detected vehicles stopping or departing after a stop.

Results

Dependent measures were accuracy in detecting blocked lanes (stopped vehicles), and latency to detect stopped vehicles, and detection when stopped vehicles departed before both lanes were blocked. Accuracy measures included:

- Correct detections of stopped vehicles.
- Misses, i.e., failures to detect stopped vehicles within 10 s.
- False alarms, i.e., incorrect detection of stopped vehicles.
- Correct detection of the departure of stopped vehicles.

The primary measure of effectiveness for this experiment was accuracy in detection of both lanes being blocked. This measure was chosen because we assumed that when both lanes are blocked, it might be judged appropriate for a visually impaired pedestrian to make a crossing. With only one lane blocked, a crossing would be less appropriate, because the presence of one idling vehicle creates noise that can mask the approach of other vehicles that might not stop, and thus pose a hazard to the pedestrian.

Table 1 shows the results for detection of vehicles blocking each of the lanes. A correct detection, or "hit", was scored if the participant indicated both lanes were blocked within 10 s. A false alarm was scored if at any time before both lanes were blocked the participant indicated both lanes were blocked. A miss was scored if the participant did not detect both lanes were blocked within 10 s. As can be seen, 5 of the 7 participants had superior hit rates in the treatment condition compared to the control. This difference was statistically significant, $z = -2.0$, $p < 0.05$ by Wilcoxon signed ranks test.[8] However, every participant had at least one false alarm in the treatment condition. False alarms are cause for concern because they imply that the individual might make crossings believing that stopped vehicles block both lanes when in fact they would vulnerable to vehicles approaching at speed in the open lane. False alarm rates with and without the strips were roughly the same. Each participant was exposed to four trials, two each in treatment and control conditions, in which the first vehicle to yield departed after 10 s. On those trials both lanes never became blocked because the second vehicle to yield arrived after the first had left. Six of the seven participants detected all departures of the first vehicle. One participant missed one departure in the treatment condition.

In the treatment condition participants also detected both lanes were blocked more quickly than in the control condition, $F(1, 6) = 26.4$, $p < 0.01$. Mean time to report both lanes were blocked was 3.5 s in the control condition and 2.3 seconds in the treatment condition.

Detection of two vehicles arriving at the same time was better in treatment condition than in the control, $t(6) = 2.3$, $p < 0.05$. Overall, detection of vehicles arriving at the same time did not differ from vehicles arriving one at a time. It appears that whether vehicles arrive separately or together may not be critical to a correct detection.

Detection of individual vehicle stops was also recorded. A hit was scored whenever the participant correctly identified, within 10 s, the presence and lane position of a stopped vehicle. A miss was scored if a stopped vehicle was not identified as stopped in the specified lane within 10 s. A false alarm was scored when a vehicle was identified as stopped in a specified lane when it was not. When a stopped vehicle was associated with the wrong lane, a miss was scored for one lane and a false detection for the other. Stops were identified with the wrong lane in 19 percent of the misses in the control condition and 13 percent of the misses in the treatment condition.

Some participants incorrectly reported stops in a particular lane more than once within a trial. Multiple false alarms were possible in the single lane case, because participants could recognize that a vehicle was not stopped in that lane, and could subsequently wrongly identify another stopped vehicle. This was not the case in scoring for detection of both lanes blocked, because in that scoring a trial ended as soon as the participant indicated both lanes were blocked. Because of the complexity of false alarm interpretation in the single vehicle case, only hit rates are reported, and these should be interpreted with caution.

Figure 1 shows the proportion of correct identifications of stopped vehicles by condition, lane, and the lane in which the first yield occurred. Overall, performance was better in the treatment condition, $F(1, 6) = 15.4$, $p < 0.01$. Identification tended to be more accurate when the first vehicle to yield was in the far lane, $F(1, 6) = 12.3$, $p < 0.05$. The 3-way interaction of condition, lane to yield first, and lane was significant, $F(1, 6) = 10.4$, $p < 0.05$. In the control condition, performance in detecting yields in the near lane was little affected by the whether there was a stopped vehicle in the far lane. However, detection was poorest of vehicles yielding in the far lane when a vehicle was already idling in the near lane. In the treatment condition, there were no interactions. Near lane detection was consistently better than far lane detection, and both near and far lane detection was better when the vehicle in the far lane was the first to yield.

The first vehicle to yield creates noise as it idles at the crosswalk. When it idles in the lane nearest the participant, that noise can mask the later arrival of a second vehicle in the far lane. Participants were able to detect only 30 percent of the vehicles that yield in the far lane when there was a vehicle already idling in the near lane. However, when the first vehicle to yield is in the far lane, the participant can usually detect the arrival of a second vehicle that comes between the participant and the vehicle in the far lane. When a vehicle yielded in the near lane, between the participant and a vehicle already stopped in the far lane, detection performance averaged 98 percent correct detections.

At the conclusion of the yield detection tests, participants were debriefed. The full results of the debriefing have been reported previously, so only highlights are discussed in this report.[9] Four of the participants indicated that they thought the sound strips were somewhat useful. One participant was neutral on this issue, and one participant complained that the sound strips made it difficult to hear the car engines, which he listens for. It may be interesting to note that this comment came from participant 1, who, as can be seen in Table 1, performed considerably better in the treatment condition. Four of the seven participants indicated that they occasionally cross at uncontrolled locations with more than one lane when vehicles stop for them. All but one who indicated they would make this type of crossing said that it could be done only when there is no traffic noise other than the stopped vehicle or vehicles. One participant said he would walk in front on one vehicle that stops, then listen for another vehicle to stop in the other lane.

STUDY TWO

This study was conducted at a double-lane roundabout in Maryland. The roundabout had an inscribed circle diameter of 159 ft. It was a junction of a 4-lane road with a two-lane road. The exit used in the study had two 5 m (16 ft) lanes. The roadway itself was a dark colored asphalt. Two concrete transverse strips designated the crosswalk with brickwork between the strips. The exit is shown in Figure 2.

Data was collected over a four week period in the fall of 2004. The first two weeks served as the control condition. Control data was collected between 5 PM and 6:30 PM in the two weeks that preceded the end of daylight savings time. Treatment observations were made between 3:30 PM and 5 PM during the two weeks that followed the switch to standard time. Traffic counts taken in the Spring of 2004 showed that traffic volume at the exit peaked at 5 PM at a rate of about 800 vehicles per hour and that volume was symmetrically distributed about the peak. Because of the switch from daylight savings to standard time, lighting conditions were approximately the same for the baseline and treatment conditions. Because there were 10 days of testing, five in each condition, some of the same drivers were observed more than once. Trials averaged 1.5 minutes in length and there was an average of 15 trials per day. Thus, over the 90-minute test interval, the participant and orientation and mobility specialist were only at the crossing for about 23 minutes. It is estimated that, on any given test day, a daily roundabout user had about a 1 in 4 chance of participating.

The treatment consisted of installation of the sound strips in the same manner as in Study One, plus the installation of two additional signs. One of the signs, MUTCD R1-6 was mounted between the two exit lanes, contiguous with

the upstream edge of the crosswalk. The sign was 90 cm (36 in) high by 30.5 cm (12 in) wide, with its bottom mounted 61 cm (23 in) above the pavement on a breakaway post.[10] This regulatory sign directs motorists to yield to pedestrians within the crosswalk. It was included in the treatment to increase yielding and thereby increase the probability that usability of the sound strips could be fully tested. The other sign, MUTCD R1-5, was mounted on the pedestrian warning sign that was adjacent to the crosswalk on the right side of the exit. This sign was 61 cm (24 in) square. This regulatory sign directs motorists to yield "here". The purpose for adding this sign was to encourage drivers to stop at the crosswalk rather than farther away where the pedestrian might not be able to hear idling engines.

Procedures

Three video cameras were mounted atop an 8.5 m (28 ft) mast. The mast was located on a knoll on the side of the street opposite to the exit of interest and about 15 meters downstream from the exit crosswalk. One camera was used to capture the participant, Certified Orientation and Mobility Specialist (COMS), crosswalk, and vehicles approaching the exit. This camera was the only one used to capture the data reported here. A second camera was used to capture traffic in the circular roadway, and a third camera captured traffic that approached the roundabout entrance adjacent to the exit.

Before data collection began, the COMS crossed with the participant several times so that the participant could familiarize them self with the roundabout layout and traffic sounds. Although she was not visually impaired, the COMS carried a white cane and wore sunglasses. Every participant had either a white cane or a guide dog. Before each trial, the participant and COMS waited on the sidewalk approach to the exit crosswalk. When no vehicles were within about 15 m, they stepped to the edge of the crosswalk ramp and the COMS began tapping her white cane in the street at a rate of one tap per second. The COMS stood with one foot over the curb edge, in the gutter, so that she was technically in the crosswalk. The participant stood completely on the sidewalk to the left (upstream) of the COMS.

The tapping of the cane signaled the beginning of a trial. A trial ended when one of the following occurred:

* The participant indicated that both lanes were blocked by stopped vehicles.
* One of the lanes was blocked for 10 s or more and traffic was backing up.
* Both lanes were blocked and the participant failed to indicate this within 10 s.
* A pedestrian or motorist stopped to help the participant and COMS cross.
* Three minutes elapsed.

In most cases, the COMS and participant crossed the street at the end of a trial. Rest periods between trials varied from several seconds to several minutes. However, new trials did not begin until all drivers who might have seen the end of the preceding trial departed

Participants verbally indicated when vehicles stopped, when stopped vehicles departed, and when both lanes were blocked. Unlike the previous experiment, participants were not asked to indicate the lane in which vehicles stopped.

Results

Across all participants, 151 trials were observed: 65 in the control condition and 86 in the treatment condition. As shown in Table 2, during trials 1944 vehicles approached the observed exit crosswalk. Most of those vehicles, 1671 passed the crosswalk without stopping. Only 273 vehicles, 14 percent, stopped at least momentarily before passing the crosswalk. In the control condition, 11.5 percent of the vehicles stopped. In the treatment condition 16.7 percent of vehicles stopped. This result was consistent with the hypothesis that the Yield to Pedestrian sign that was placed between the lanes induced a greater proportion of drivers to stop, $X^2 = 24.4$, $p < 0.0001$.

Although the in-street sign may have increased compliance with state law, the nature of the compliance was less than optimal for the effectiveness of the sound-strip treatment. Figure 3 shows the longitudinal distance from the crosswalk to the front of vehicles that stopped in the near lane. Dotted lines in the figure represent the distance from the crosswalk of the sound strips. It can be seen that the majority of vehicles in the near lane did not fully traverse the strips. Figure 4 shows a video capture of two vehicles that stopped well upstream of the crosswalk and, thus, did not cross the sound strips. Vehicles that stopped 6 meters from the crosswalk would have crossed the furthest upstream strip with their front wheels. Their rear wheels would not have crossed either of the upstream sound strips.

Only drivers that stopped within 2 meters of the crosswalk would be likely to have triggered sounds from both upstream strips with both front and rear wheels. Thus, only 24 of the 194 vehicles that stopped in the near lane are likely to have generated the intended sound pattern.

In the near lane, stopping distance from the crosswalk did not vary significantly with treatment, t (77) = 0.061, $p >$ 0.10. However, vehicles that stopped in the far lane stopped further from the crosswalk in the treatment condition than in the control condition, t (77) = 3.4, $p < 0.01$. Figure 5 shows the distribution of far-lane stopping distances in the control and treatment conditions. We have no explanation for this unexpected phenomenon.

Table 3 shows the outcome of the 151 trials. The participant numbers refer to the same individuals as they did in Study 1. The table includes an outcome not anticipated in the research plan: many trials ended when a passing pedestrian or motorist stopped to assist the blind pedestrians: a Good Samaritan act. These were labeled *Good Sam* in the table. A trial was given this designation when: (1) pedestrians stopped to provide assistance, (2) drivers got out of their cars to provide assistance, (3) drivers engaged in some overt behavior to influence other drivers to stop, or (4) drivers interacted with the pedestrians in ways that disrupted their ability to listen for other traffic.

The *time out* category included two different outcomes: (1) three minutes passed without two vehicles blocking the lanes, or (2) the COMS determined that an individual vehicle or traffic was excessively delayed. The latter would occur when a vehicle or series of vehicles yielded in the near lane, but no vehicles would yield in the far lane.

The remaining categories are similar to those used in Study 1. Unlike the closed course study, it was rare for two vehicles to stop side-by-side in the roundabout exit. In most cases, both lanes were considered blocked if vehicles stopped such that it would be difficult for subsequent vehicles to maneuver into the roundabout exit. The percentage of trials classified into each category, is shown in Table 3. These proportions differed significantly between control and treatment conditions, $X^2(4) = 34.3$, $p < 0.0001$. However, it is unlikely that the difference in hits, false alarms, and misses are attributable to the treatment, as most yielding vehicles were not producing the desired sound cues by running over the sound strips. Practice, or a shift in the participants' response criteria, is a more likely cause to explain the performance differences. In any case, the observed changes were not in the predicted direction.

Figure 6 shows the distribution of delays between the time both lanes were blocked by fully stopped vehicles and the time when participants indicated that the lanes were blocked. The modal delay is 3 s. In three cases participants identified the blocked lanes 2 s before both vehicles came to a complete stop. This apparent anomaly may be attributed to participants shifting from the strategy they normally use to detect stopped vehicles – listening for idling engines – to listening for silence after detecting approaching vehicles.

When the pedestrians do not immediately begin to cross, drivers may move on. To provide an estimate of how long drivers may wait, the amount of time drivers waited was tabulated. If the pedestrians crossed or stepped away from the curb, then the amount of time drivers waited was not included. This procedure yielded delay times for 28 drivers in the control condition and 56 drivers in the treatment condition. In the control condition, drivers waited an average 10.8 s. In the treatment condition, drivers waited an average of 4.7 s. In the control condition, wait times varied between 1 and 25 s. in the treatment condition, wait times varied between 1 and 20 s. The difference in wait times was statistically reliable, t (39) = 5.1, $p < 0.01$. The difference in willingness to wait may have been because drivers who were induced to stop by the in-street sign were not as committed to wait as drivers were who stopped without the added inducement. If this hypothesis is correct, then the benefit of in-street signs to visually impaired pedestrians is diminished. The bulk of the drivers who are influenced by the sign appear to be willing to wait only 3 s to 6 s. Thus, these drivers may pull away just as the visually impaired pedestrian begins to cross.

CONCLUSIONS AND RECOMMENDATIONS

Study One showed that the selected pavement treatment increased the proportion of double-yields that are detected and decreased the amount of time required to detect the yields. False detections of yields were not reduced by the treatment, and this problem still needs to be addressed.

Study Two showed that motorists may stop long before they reach the roundabout exit, so that the pavement treatment in the exit was rendered ineffective. Before sound treatments similar to the one evaluated in these studies can be made to work, (1) the frequency of motorist yielding would need to increase, (2) the location of the yields

would need to be more consistent, preferably closer to the crossing, (3) motorists who yield would need to show more consistent patience, and (4) the problem of false yield detections needs to be solved.

Both of the present studies focused on double-lane roundabouts. It is possible that a pavement treatment similar to that used in these studies could be effective at single-lane roundabouts. Study One showed that the second vehicle to yield is difficult to detect when it stops in the far lane and quite easy to detect when it stops in the near lane. Single lane roundabouts do not present the same challenges and might allow higher detection rates than were observed in Study One. However, single lane operations were not observed in these studies, and the suggestion that pavement treatments would be effective in the single-lane case needs to be rigorously tested. Until such tests are conducted, the possible effectiveness of sound strips for single-lane roundabouts should not be assumed.

The finding that motorists tend to stop well upstream of the crosswalk may suggest that roundabout crosswalks should be situated two or more vehicle lengths away from the inscribed circle. Such a design would minimize the likelihood that vehicles that yield to pedestrians will obstruct the circular roadway. It might also increase the likelihood that an effective pavement treatment to cue visually impaired pedestrians can be devised. Again, however, we caution that we have not tested roundabout exits with longitudinal storage areas of more than 20 feet. Moving the crosswalk further from the roundabout may change driver behavior in other ways, such as lowering the willingness of drivers to yield and increased speed at the crosswalk. Moving the crosswalk, in many cases, would increase pedestrian travel distance. Therefore, the effects of situating the crosswalk further from the circular roadway need to be carefully studied to ensure any benefits that may result are not offset by disbenefits.

REFERENCES

1   United States Access Board. (2003). Pedestrian Access to Modern Roundabouts: Design and Operational Issues for Pedestrians who are blind. http://www.access-board.gov/publications/roundabouts/bulletin.htm, Retrieved January 24, 2005.
2   Pietrolungo, A. CMCB takes no prisoners. The Braille Forum, XXXVIII, April, 2000.
3   Guth, D., Ashmead, D., Long, R., Wall, R., and Ponchillia, P. (2002). Blind and Sighted Pedestrians at Roundabouts. Manuscript submitted for publication.
4   United States Access Board. (2002). Draft Guidelines for Accessible Public Rights-of-Way. http://www.access-board.gov/rowdraft.htm. Retrieved January 25, 2005.
5   Sauerburger, D. (1989). "To cross or not to cross: Objective timing methods of assessing street crossings without traffic controls," RE:view, 21, **3**, 153-161.
6   Sauerburger, D. (1995). Safety Awareness for Crossing Streets with No Traffic Control. *Journal of Visual Impairment and Blindness*, 89, 5.
7   Sauerburger, D. (1999). Developing Criteria and Judgment of Safety for Crossing Streets with Gaps in Traffic. *Journal of Visual Impairment and Blindness*, 93, 7, 447-450.
8   Meddis, R. (1984). Statistics Using Ranks. Basil Blackwell Inc., New York, NY.
9   Davis, G. W., and Inman, V. W. (2004). *Pedestrian Access to Roundabouts: Closed Course Test of Yielding Vehicle Detection System*. Unpublished paper presented at Institute of Transportation Engineers Annual Meeting, Lake Buena Vista, FL.
10   United States Department of Transportation. (2001). Manual on Uniform Traffic Control Devices. Washington, DC.

Inman, Davis, and Sauerburger

List of Tables and Figures

Table 1. Detection Accuracy for Vehicles Blocking Each Lane.

Participant	Hits Control	Hits Treatment	False Alarms Control	False Alarms Treatment	Misses Control	Misses Treatment
1	47%	87%	7%	7%	47%	7%
2	19%	69%	13%	13%	69%	25%
3	50%	50%	13%	13%	38%	38%
4	19%	38%	6%	13%	75%	50%
5	44%	63%	0%	13%	56%	25%
6	63%	56%	31%	13%	6%	31%
7	13%	38%	0%	19%	88%	44%
Mean	36%	57%	10%	13%	54%	31%

Table 2. Drivers' Response to Presence of Blind Pedestrians in Crosswalk.

Driver Behavior	Control	Treatment	Total
Stopped	115	158	273
Continued without Stopping	881	790	1671
Total	996	948	1944

Table 3. Trial Outcomes.

Participant	Control Hits	Treatment Hits	Control False Alarm	Treatment False Alarm	Control Time Out	Treatment Time Out	Control Miss	Treatment Miss	Control Good Sam	Treatment Good Sam
2	19%	20%	19%	7%	13%	7%	19%	27%	31%	40%
3	43%	14%	36%	14%	14%	43%	0%	24%	7%	5%
4	8%	6%	17%	0%	8%	50%	33%	25%	33%	19%
5	15%	6%	0%	0%	38%	56%	0%	13%	46%	25%
7	10%	11%	0%	6%	50%	28%	0%	39%	40%	17%
Mean	19%	12%	14%	5%	25%	37%	32%	21%	10%	25%
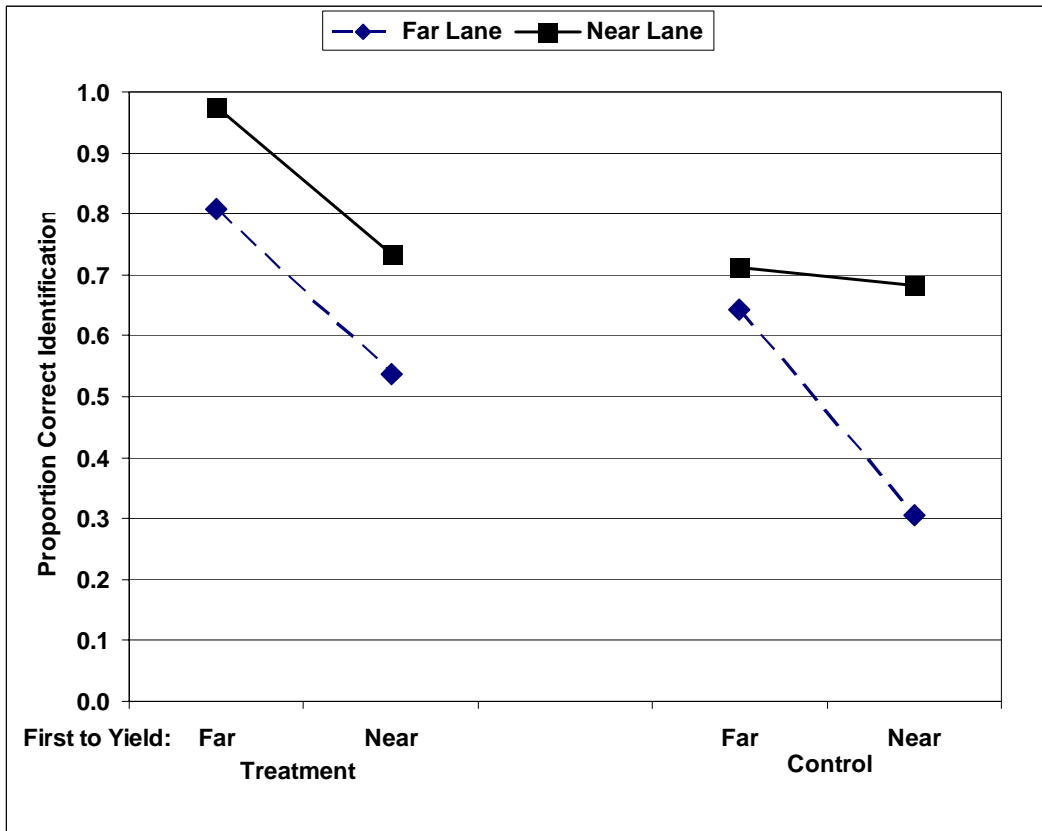
Figure 1. Proportion of correct identifications of stopped vehicles by test condition, first to yield lane, and the lane.

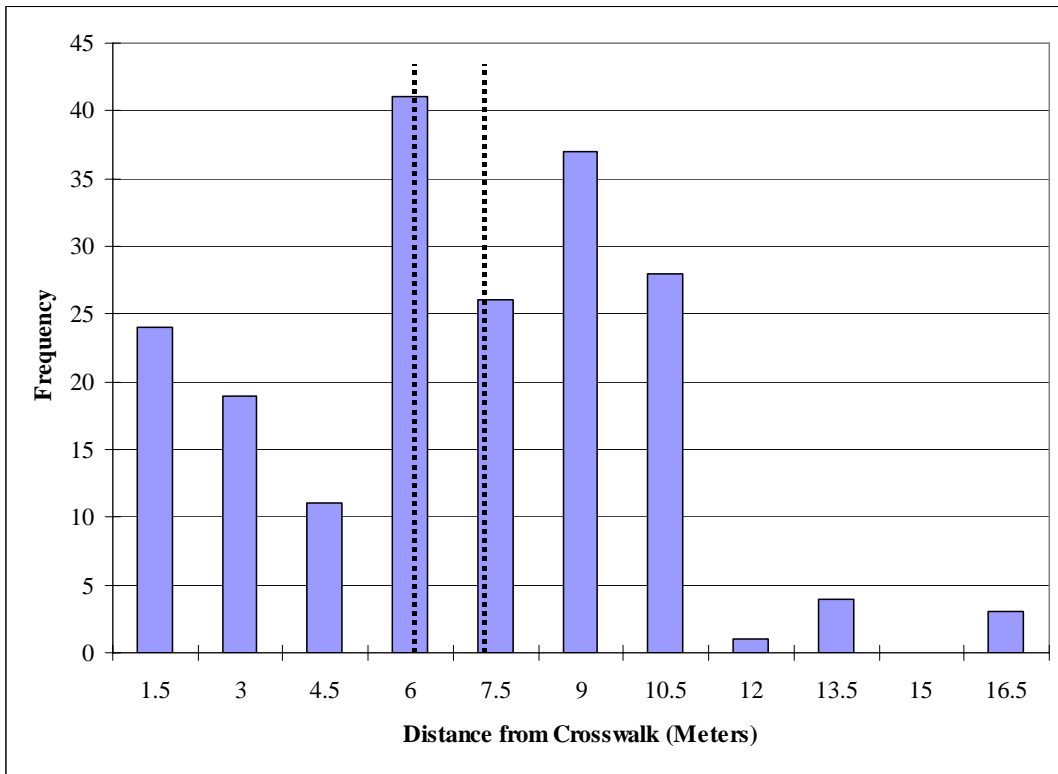Figure 2. Roundabout exit in baseline configuration.

Figure 3. Distance from crosswalk of vehicles stopping in the near lane.
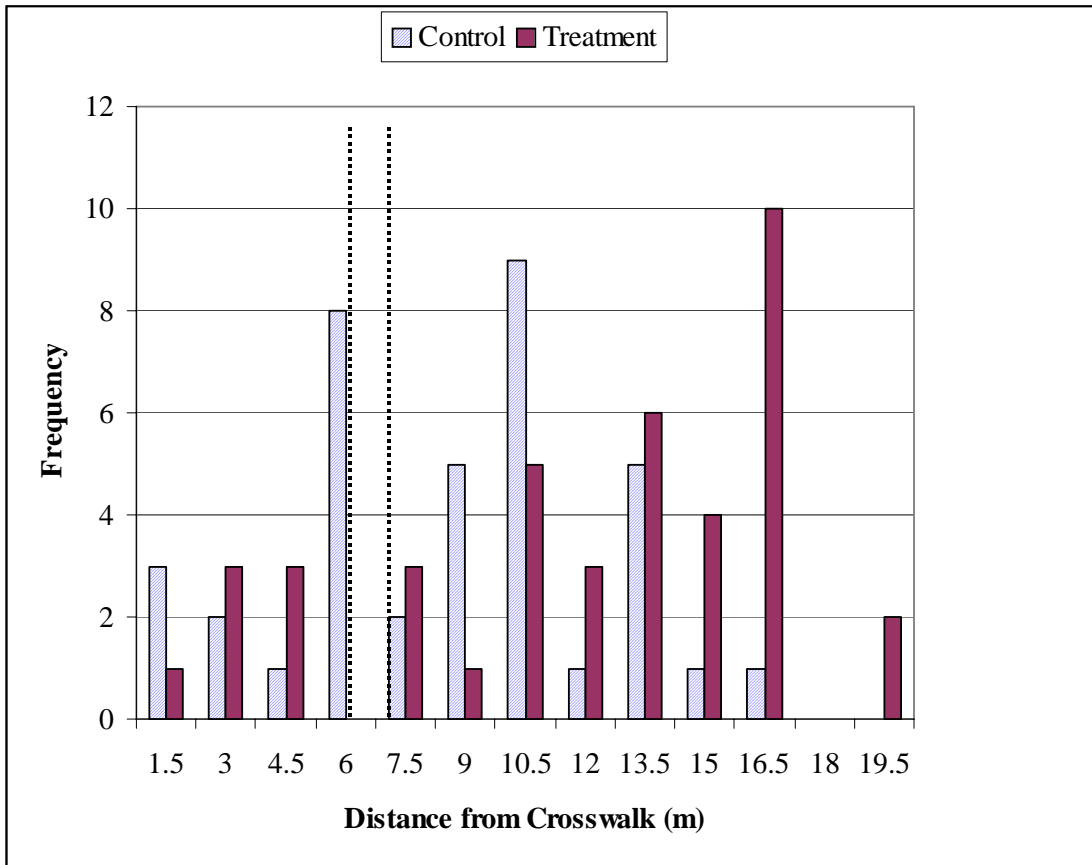
Figure 4. Two vehicles that stopped for the pedestrians.

Figure 5. Distance from crosswalk that vehicles in the far lane stopped is shown as a function of treatment condition.
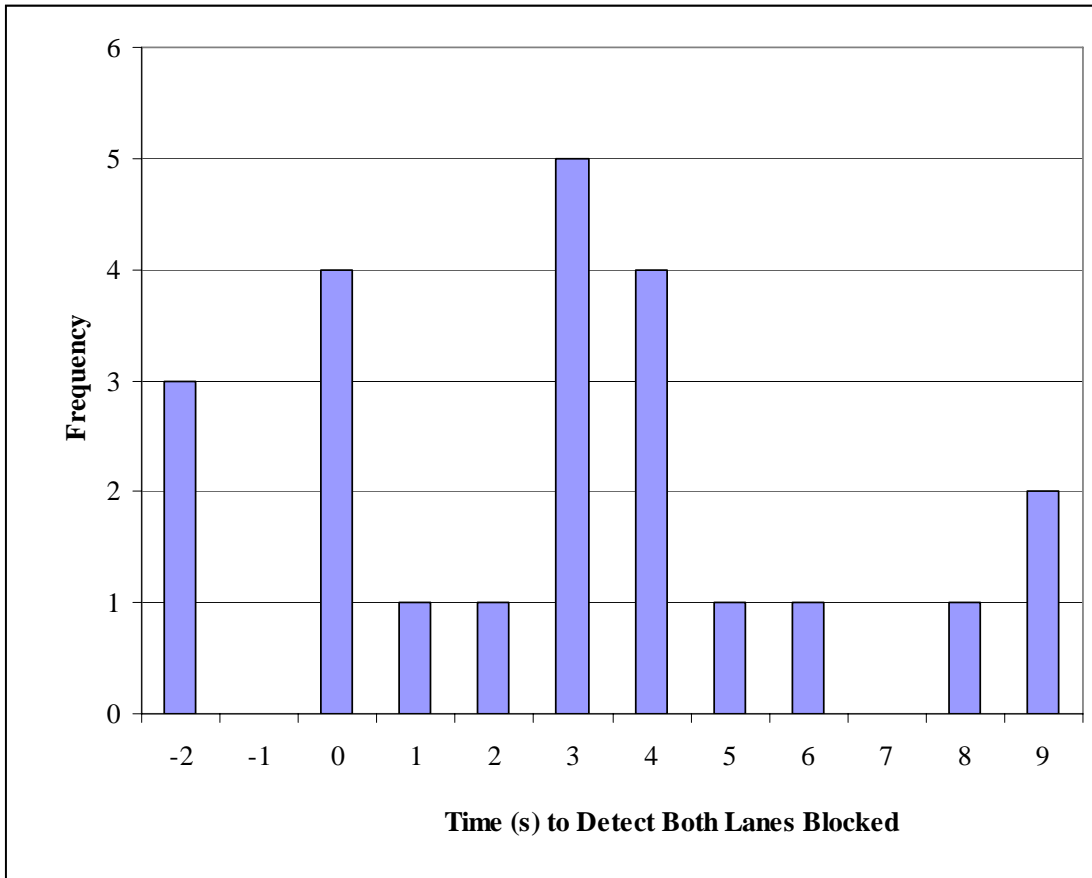
Figure 6. Frequencies of delay between the time both lanes were blocked by stopped vehicles and correct detection of that state by participants.
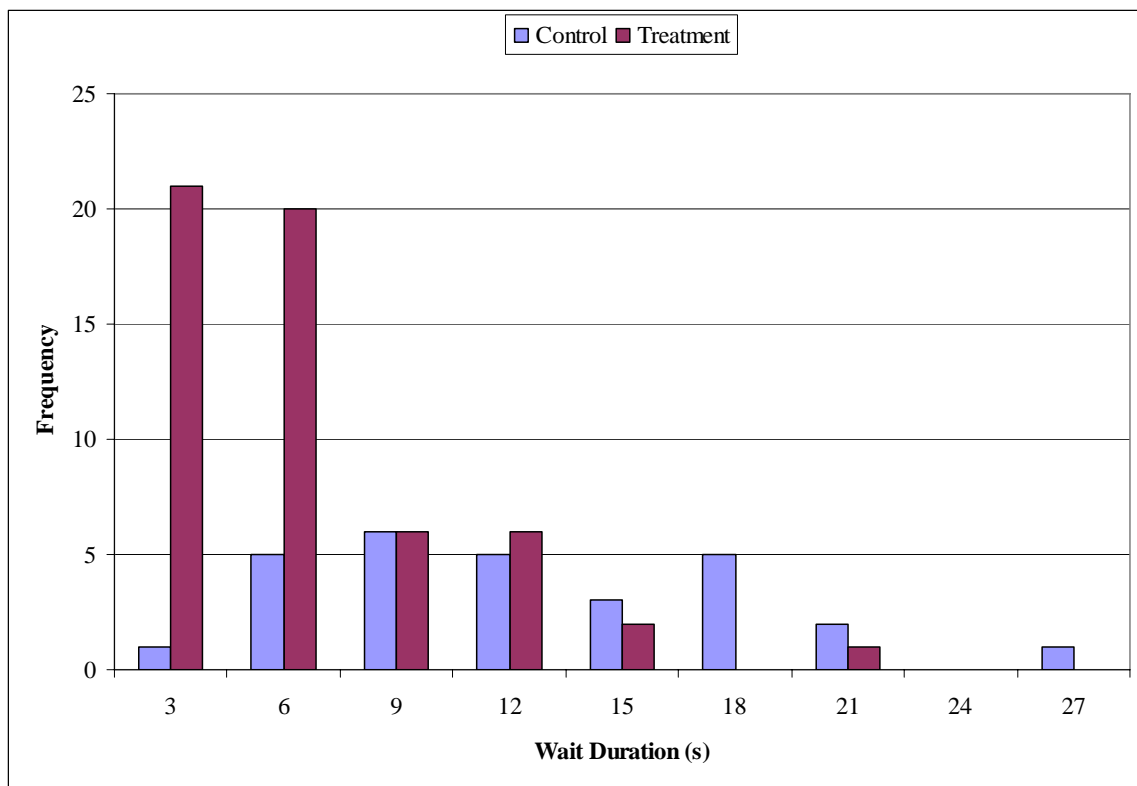
Figure 7. Amount of time drivers waited before moving on.