EVALUATION OF THE RECTANGULAR RAPID FLASH BEACON AT A PINELLAS TRAIL CROSSING IN ST. PETERSBURG, FLORIDA

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ABSTRACT

This paper is an evaluation of how a pedestrian safety device, the rectangular rapid flash beacon (RRFB), performed at a street crossing of the Pinellas Trail, a shared-use path, where the vast majority of trail users are bicyclists. Before and after video data were collected for more than 1,000 bicyclists and pedestrians with an elevated camera beside the trail and several hundred feet from the actual trail crossing. Trail user delay before starting to cross was reduced after installation of the RRFB. Bicyclists and pedestrians yielded considerably less, and motorists considerably more, after the installation. Overall, motorist yielding increased from 2 percent before to 35 percent after. When the flasher was activated, motorist yielding was 54 percent. In the before period, 82 percent of the trail users were able to cross all the way across the intersection, while 18 percent were trapped in the middle. In the after period, comparable values were 94 percent and 6 percent. Overall, the installation of the RRFB increased the safety of trail users at the crossing. However, the device is not fail safe, and communities employing the device at trail crossings should take note of this. Perhaps some additional education effort would be helpful in (1) increasing the percentage of trail users pushing the button, and (2) increasing motorists’ knowledge about the requirement to yield to pedestrians in such crossings. Perhaps of more benefit would be periodic police enforcement operations, or the development of a passive detection system.

INTRODUCTION

The City of St. Petersburg, Florida has undertaken a variety of improvements in recent years to increase bicycle and pedestrian safety. The Neighborhood Transportation section, an office within city government, is involved in the planning and implementation of bicycle and pedestrian facilities. Improvements have included the installation of bicycle lanes, a green-colored bicycle lane weaving area, and upgrading of many uncontrolled pedestrian crosswalks throughout the city. This paper is an evaluation of how a pedestrian safety device, the rectangular rapid flash beacon (RRFB), performed at a street crossing of the Pinellas Trail, where the vast majority of trail users are bicyclists.

RRFB's had been previously installed at 19 St. Petersburg uncontrolled midblock pedestrian crosswalks. An evaluation of 18 of these 19 locations by Shurbutt, Van Houten, and Turner (*1*) indicated that the system wide average motorist yielding to pedestrians improved from less than 1 percent to approximately 80 percent after RRFB's were installed.

For the current study, it was decided that the RRFB should be installed and evaluated at a location where the Pinellas Trail, a shared-use path, crosses 22nd Avenue N, a minor arterial street with two lanes in each direction, 15,000 vehicles per day and posted speed limit of 40 mph. Depending on season, the Pinellas Trail has approximately 1,300-2,000 trail users per day, with about 80 percent being bicyclists. It was felt that the RRFB would make the trail crossing safer by increasing the yielding of motorists to bicyclist and pedestrian trail users.

Figure 1 shows a close-up view of a single RRFB beacon and the system installed at the trail crossing. Four rectangular yellow LED indicators which flash rapidly on both front and back in a wig-wag sequence (left and then right) were installed, one at the edge of the street on each approach and two more indicators in the median. These face approaching motorists and indicate that a trail user is present and that motorists should stop or yield. The wig-wag sequence produces a "stutter-flash effect" similar to some emergency vehicles. The unit is solar-powered and uses radio frequency transmitters to link the devices so a depression of any of the call buttons activates the flashers on all signs. A separate LED faces the pedestrian and flashes to indicate the system is operating. An audible message instructs users to wait for motor vehicles to stop before crossing.

LITERATURE REVIEW

The literature is focused on the effects of different signing and marking countermeasures for pedestrians crossing roadways. However, these studies are relevant in understanding how pedestrians and motorists react to different traffic control systems and in determining the most appropriate measures of effectiveness for the evaluation of the RRFB at the trail crossing in this study.

FIGURE 1 RRFB close-up and system installation at the Pinellas Trail crossing and 22nd Avenue N.

The problem of pedestrians being struck while crossing the roadway is not new. Zegeer, Opiela, and Cynecki (*2*) examined crashes from 15 cities and found that 43 percent were struck while crossing against the pedestrian signal. Hunter, Stutts, Pein, and Cox (*3*) used data from six states to learn that as many as 26 percent of pedestrian-motor vehicle crashes occur at uncontrolled midblock locations. A more recent study by Zegeer, Stewart, Huang, Lagerwey, Fegan, and Campbell (*4*) showed that on roadways under certain conditions (i.e., multilane roadways having traffic ADT's of 12,000 vehicles per day or more), sites with marked crosswalks (and with no additional pedestrian treatments present) had higher pedestrian crash rates than comparable roadways without marked crossings. Pedestrian and traffic volumes and other site conditions were controlled for in the analysis. Recommendations indicated that roadways with high motor vehicle traffic volume should not be marked unless additional safety features were provided for pedestrians.

Over time, a variety of signing and marking techniques have been employed to enable safer pedestrian crossings. Huang, Zegeer, and Nassi (*5*) evaluated an overhead crossing sign in Seattle, Washington; pedestrian safety cones with the message “State Law: Yield to Pedestrians in Your Half of Road” in New York State and Portland, Oregon; and pedestrian-activated overhead signs with the message “Stop for Pedestrians in Crosswalk” in Tucson, Arizona. The safety cones and the overhead crosswalk sign in Seattle showed promise for pedestrian safety effects on low speed, two-lane roads by increasing yielding by motorists. The pedestrian-activated signs in Tucson showed less promise, perhaps because they were installed on four and six lane arterials with higher speeds.

Hughes, Huang, Zegeer, and Cynecki (*6*) evaluated whether automated pedestrian detectors (both infrared and microwave), used along with standard pedestrian push buttons, would reduce crossing against the signal and pedestrian-motor vehicle conflicts. Results showed a significant reduction in both variables.

Huang, Hughes, Zegeer, and Nitzburg (*7*) evaluated an in-roadway flashing crosswalk installed in Orlando, Florida in 1997. Small positive effects were shown for increasing motor vehicle yielding to pedestrians, reducing motor vehicle speeds, and reducing pedestrian-motor vehicle conflicts. The device was not very effective in getting pedestrians to use the crosswalk, and interviews showed that many pedestrians did not understand the working of the crosswalk.

Turner, Fitzpatrick, Brewer, and Park (*8*) undertook a national study to examine engineering treatments used to enhance pedestrian safety in marked crosswalks. Three categories of devices were studied: (1) red signal or beacon devices, (2) "active when present" devices, and (3) enhanced and high visibility treatments. The red signal or beacon devices included midblock signals, half signals, and high intensity activated crosswalk (HAWK) signal beacons, and these devices showed motorist yielding rates greater than 94 percent for all study sites, nearly all of which were on arterial streets. Pedestrian crossing flags and in-street crossing signs had 65 percent and 87 percent motorist yielding rates, with most of these treatments used on low-volume, two-lane streets. Yielding rates varied by study site, and speed of traffic and number of lanes were factors.

Fitzpatrick and Park (*9*) used the empirical Bayes method to perform a before-after safety performance study of HAWK signals. Crash data were obtained for 21 HAWK sites and 71 reference sites. Results indicated that the HAWK signals were associated with a 28 percent reduction in all crashes and a 58 percent reduction in pedestrian crashes.

Several studies by Van Houten and others add knowledge to how pedestrians react to various signal systems and/or associated features. One study by Van Houten, Ellis, Sanda, and Kim examined the effects of pedestrian push buttons that give audible and visual feedback (*10*). The data were collected at two intersections in Miami Beach, Florida. Results showed that the push buttons were associated with a statistically significant increase in the percentage of (1) cycles where pedestrians pushed the buttons, and (2) pedestrians who waited for the walk indication. The latter result was also associated with fewer pedestrians trapped in the roadway.

Another Miami-Dade County study by Van Houten, Ellis, and Kim (*11*) examined various minimum green times and the effect on the pedestrians waiting for a midblock walk signal. Data were collected at two intersections, one on an arterial multilane roadway with two-way traffic, and the other a multilane roadway with one-way traffic. The minimum green time varied between 30 and 120 seconds at each location. When the minimum green time was increased, results indicated that (1) the rate of pedestrians complying with the walk signal decreased, and (2) the percentage of pedestrians trapped at the centerline increased. For the location with one-way traffic and a lower average daily traffic, the pedestrian compliance decreased more rapidly as minimum green time increased, most likely due to the increased ability to find an acceptable gap in traffic.

Both the Huang et al. (*5*) and the Turner et al. (*8*) studies had shown increased motorist yielding compliance with in-roadway signs. Ellis, Van Houten, and Kim (*12*) examined whether placing such signs at the crosswalk or 20 or 40 feet from the crosswalk would alter the effectiveness. Data were collected at three intersections on Collins Avenue in Miami Beach, Florida, a two-way street with one lane in each direction, parking on both sides of the street, and an average daily traffic of 29,500. All three individual placements of the signs produced a significant increase in motorist yielding, and there were no differences in yielding depending on the sign placement. Using all three signs in combination was no more effective than the use of a single sign at the crosswalk. Significantly fewer pedestrians were trapped in the crosswalk at one of the intersections. Being trapped was rare at the other two locations.

Van Houten, Ellis, and Marmolejo (*13*) conducted two experiments in Miami-Dade County, Florida involving the use of standard pedestrian warning signs accompanied with LED flashers for each sign. The signs and flashers were used at multilane crosswalks at two test locations. Four signs with the flashers were used at each crosswalk. Staged pedestrians were used in baseline, and yielding was scored once the pedestrian placed at least one foot in the crosswalk. Florida law requires motorists to yield under this condition. Resident pedestrians were scored after baseline. Results showed that motorist yielding increased significantly, from approximately 3 percent or less yielding in baseline to approximately 65 percent after the installation of the signs and flashers. The yielding rate was actually a bit higher for local pedestrians, perhaps because they were more assertive in their attempt to cross. Evasive conflicts and the proportion of pedestrians trapped in the center of the roadway also significantly decreased. A second experiment also employed LED white lighting to illuminate the departure curb and the first four feet of the crosswalk at another location. The addition of the LED lighting did not improve the effectiveness of the signs and flashers alone. Observers noted that the pad lighting was difficult to see when the flashers were in operation.

Shurbutt, Van Houten, and Turner (*1*) continued with three more experiments of the RRFB's at 18 uncontrolled pedestrian midblock crossings in St. Petersburg, Florida mentioned earlier in the introduction. The first experiment basically compared the operation of two sets of RRFB's (at the edge of the roadway) with four sets of beacons (at the edge of roadway and in the median island). Four uncontrolled midblock locations with slightly varying attributes were used. Overall, motorist yielding showed a statistically significant increase from 18 percent at baseline to 81 percent with a two-beacon system to 88 percent with a four-beacon system. Yielding distance also increased, with the percentage of vehicles yielding at greater that 100 feet basically doubling. Passes or attempted passes of vehicles stopped for pedestrians also decreased. In the second experiment a standard round, overhead, yellow flashing beacon and a standard round, side-mounted, yellow beacon were compared with a two-beacon and then a four-beacon flash system at two different locations. Motorist yielding increased from 11 percent baseline to 16 percent with overhead standard beacon to 78 percent with two-beacon flash to 88 percent with four-beacon flash at one location. The differences were comparable but not quite as large at the second location. The motorist yielding distance was not quite as clear cut as in the first experiment, but the percentage of vehicles yielding at greater than 100 feet more than doubled from the two-beacon system to the four-beacon system (5.6 to 12 percent). The third experiment compared two- or four-beacon systems to baseline at 18 separate locations over time. The average baseline yielding percentage for all 18 sites was 0.88 percent. The average yielding percentage for all 18 sites was 78 percent after seven days, 85 percent after 30 days, and approximately 80 percent a year later.

Shurbutt and Van Houten (*14*) extended previous work on RFFB's by examining data from 22 sites in the cities of St. Petersburg, FL; Washington, DC; and Mundelein, IL. Using general time-series regression modeling, there was "an immediate and large increase in yielding from the baseline to day 7, a small but statistically significant additional increase from day 7 to day 30, a minor and not statistically significant decrease at day 60, and a general trend after day 60 that has little slope across the remaining observation days." Thus, the increase in yielding held over the two years of the study. Yielding was 87.8 percent at locations with four RRFB's (one on right-hand side of road and one in median for each approach) versus 81.2 percent at locations with two RRFB's (one on right-hand side for each approach). Yielding after 30 days of installation was increased from 72 to 89 percent when LED's were aimed toward the eyes of approaching drivers instead of parallel to the roadway. Night data at one location showed yielding of 99.5 percent with a four-beacon RFFB system.

The Federal Highway Administration (FHWA) granted Interim Approval for the optional use of Rectangular Rapid Flashing Beacons (RRFB) as warning beacons to supplement standard pedestrian crossing or school crossing signs at crosswalks across uncontrolled approaches in July 2008 (*15)* (see http://mutcd.fhwa.dot.gov/resinterim_approvals.htm).

THE EXPERIMENT

The decision had been made by the Neighborhood Transportation section to install a safety treatment at a street crossing with the Pinellas Trail. A consultant examined candidate locations and recommended that RRFB's be installed at 22nd Avenue North and the trail. The "before" condition of the trail crossing at 22nd Avenue North did not have a median of any kind, and the consultant recommended that a striped, center refuge island be installed due to the numbers of interacting trail users and motor vehicles at the crossing. The RRFB system was installed on August 2, 2008 (Figure 2) and included beacons and signs on the edge of the roadway and in the median (four beacon system), as well as push buttons to activate. The vendor was Stop Experts, Inc., and the cost of the system was $26,050.

FIGURE 2 RRFB system and close-up view of call button at the Pinellas Trail crossing.

The experimental design was to collect video data of trail users before and after the installation of the RRFB. An elevated camera was set up beside the trail and several hundred feet from the actual trail crossing, and video were collected from both directions of travel. Data were collected at various times of the day on both weekdays and weekends when it was not raining.

The actual installation of the RRFB took a long period of time as various procedural matters were agreed to by the city and county. “Before” video data were collected in September and October of 2006 and October of 2007 in conjunction with trips made for another study being conducted in St. Petersburg. The “after” video data were collected in December of 2008. Data were collected during daylight hours for 7 to 10 days during the before and after periods.

DATA REDUCTION

From the “before” and “after” video data, a number of measures of effectiveness and other attributes were coded. The bicyclist or pedestrian or other trail user (e.g., skater) was the basic unit of analysis. For each trail user passing across the trail intersection, gender and helmet use (if applicable) were recorded, along with their approach position (vast majority on the trail), direction, some information about the flasher push buttons in the after period, and delay to starting across the trail intersection. The vast majority of cyclists approached on the trail, although a few approached from the sidewalks parallel to the roadway.

The interactions between trail users and passing motor vehicles were also studied. As many as four interactions were coded for each trail user. On some occasions, a trail user proceeded through the intersection without any motorists present. These were coded as no interaction or “none.” When the trail user interacted with motorists at the crossing, an avoidance maneuver, conflict, or no interaction was coded. An avoidance maneuver was defined as a change in speed or direction by either the trail user or motorist to avoid the other (e.g., minor braking by the motor vehicle). A conflict was defined as a *sudden* change in speed or direction by either the trail user or motorist to avoid the other (e.g., major braking by the motor vehicle).

Additional information associated with each interaction was coded. The type of interaction was coded as bicycle-motor vehicle or pedestrian-motor vehicle, depending on the interacting parties. The main dependent variable coded was whether the trail user or motorist yielded to the other. Yielding was defined as slowing or stopping to give way to the other party at the trail crossing. Finally, when an avoidance maneuver or conflict occurred, the responses of the trail user and the motorist were coded.

Bicyclist response categories were:

- did not start
- kept moving safely (e.g., looked and used appropriate gap to cross)
- kept moving recklessly (e.g., risky crossing based on available gap)
- no change
- slows or stops pedaling
- slight direction change
- brakes
- major direction change
- full stop
- unsure

Other trail user responses (vast majority walkers) were:

- did not start
- kept going safely
- kept going recklessly
- no change
- slows
- stops walking or running
- stops quickly
- steps back
- jumps out of way
- runs
- other
- unsure

Motorist response categories were:

- no change
- slows
- slight direction change
- brakes
- major direction change
- full stop

- unsure

ANALYSIS AND RESULTS

Trail Users and Equipment Operation

Data were collected for four hundred trail users in each of the before and after periods. Chi square tests were used to compare the distributions. General findings from the video data for trail user characteristics and equipment were as follows:

- 82 percent of the trail users were bicyclists, 13 percent walkers, 2 percent skaters, 1 percent joggers, 0.9 percent walkers pushing a cart or stroller, 0.6 percent skateboarders, and 0.4 percent persons in wheelchairs. Since the vast majority was bicyclists, the remainder of the text will generally refer to non-bike users as pedestrians. The percentage of bicyclists increased from 80 percent in the before period to nearly 85 percent in the after period, but the change in the distribution was not statistically significant.
- Female trail users decreased from 32 percent in the before period to 21 percent in the after period, and the change in the overall distribution was statistically significant ($p<.001$). It is not felt that this change in the distribution was related to the experiment. The September/October period for before data versus the December period for after data could have had an effect.
- The trail users approached the crosswalk equally from the near or far side relative to the position of the camera in before and after periods - not statistically significant.
- The trail users were going equally northbound or southbound relative to the position of the camera in before and after periods - not statistically significant.
- 91 percent of the trail users approached the crossing from the trail and 9 percent from the sidewalk in the before period compared to 93 percent from the trail and 7 percent from the sidewalk in the after period – not statistically significant.
- In the before period, 35 percent of trail users approached alone, 46 percent with others, and 20 percent with others nearby. In the after period, 52 percent of trail users approached alone, 36 percent with others, and 13 percent with others nearby. The differences were statistically significant ($p<.0001$). It is not felt that this change in the distribution was related to the experiment.
- In the after period, 32 percent of the trail users pushed the button to activate the flashing signals, 49 percent did not, and for 19 percent of the trail users the button had already been pushed.
- In the before period, 80 percent of the interactions were between bicyclists and motorists compared to 83 percent in the after period. In like fashion, 20 percent of the interactions were between pedestrians and motorists in the before period compared to 17 percent in the after period. The differences were not statistically significant.
- There were only a handful of cases where the button did not work when pushed. It was discovered that the solar charging equipment was sometimes inadequate to handle the number of trail users pushing the button. A few other problems

occurred with the equipment, such as the flashers remaining on for an extended duration.

Trail User Delay

Delay was timed using a stopwatch for those users who stopped at the intersection. Delay began when either the bicyclist or pedestrian stopped for traffic and ended when they started across. This represents the initial start delay and does not include any time spent when the user had to wait in the middle of the intersection. Before the implementation of the RRFB, the average delay for pedestrians and bicyclists was 10.1 seconds with a standard deviation of 15.6 seconds. After the implementation of the RRFB, the average delay was 5.2 seconds with a standard deviation of 6.2 seconds. Thus, the implementation of the RRFB seems to have not only reduced the average delay but also the variation in the delay.

The top portion of Figure 3 shows the percentages of delay to start of crossing for trail users before and after installation of the RRFB. Shorter delays from 0-5 and 6-10 seconds increased from before to after, while longer delays were more frequent in the before period. The differences were statistically significant ($p<.0001$). The longest delay recorded was 89 seconds in the before period. In the after period, there were no delays more than 40 seconds, and these occurred because the trail user chose not to push the button to activate the flashers.

Yielding Behavior

The middle portion of Figure 3 shows the percentages of bicyclists, pedestrians, and motorists yielding in the before and after periods while interacting with each other. Only those situations where the motorist, bicyclist, or pedestrian yielded were considered for this analysis. The table includes counts of up to four interactions between a bicyclist and pedestrian with a motorist.

Bicyclists yielded in 78 percent of the interactions in the before period and 56 percent in the after period. Pedestrians yielded in 19 percent of the interactions in the before period and 9 percent in the after period. Motorists yielded in 2 percent of the interactions in the before period and 35 percent in the after period. Thus, bicyclists and pedestrians yielded considerably less, and motorists considerably more, after the installation of the RRFB. A chi square test revealed the differences to be statistically significant ($p<.0001$).

Complete Crossings versus Trapped in the Middle

The bottom portion of Figure 3 shows the number of occasions when pedestrians or bicyclists were trapped in the middle of the crossing before and after the implementation of the RRFB. In the before period, 82 percent of the trail users were able to cross all the way across the intersection while 18 percent were trapped in the middle. In the after period, 94 percent of the trail users were able to cross all the way across the intersection while 6 percent were trapped in the middle. These differences were statistically significant ($p<.0001$).

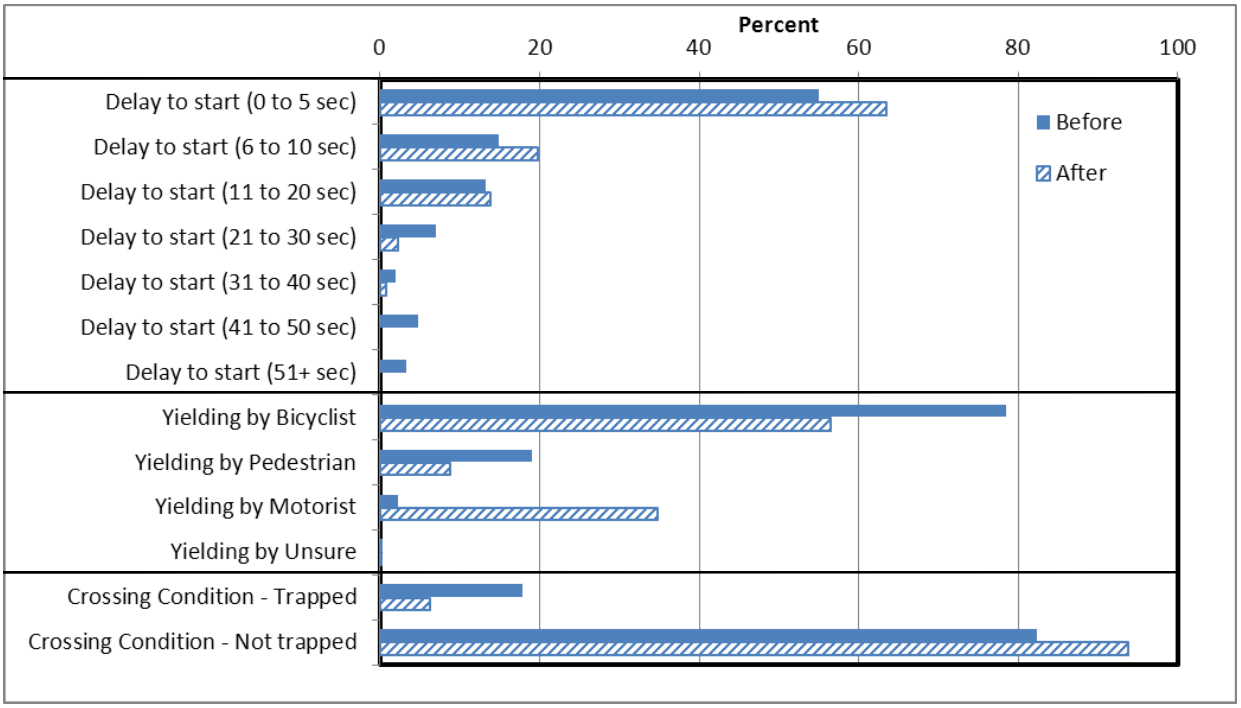

FIGURE 3 Before and after comparisons of delay to start, yielding, and crossing condition.

Yielding as a Function of Whether the Call Button was Pushed

Figure 4 shows the yielding behavior by user group in the after period depending on whether the button was pushed, had already been pushed, or was not pushed to activate the beacon. This table takes into account all the interactions (up to four) between motorists and each trail user. Sometimes a motorist would not yield to the trail user when the button was pushed because of their traveling speed. A subsequent motorist might yield. When a bicyclist yielded, the call button had *not* been pushed in 68 percent of the interactions. When a pedestrian yielded, the call button had *not* been pushed in 48 percent of the interactions. When a motorist yielded, the call button had been pushed in 54 percent of the interactions. The differences were statistically significant ($p<.0001$).

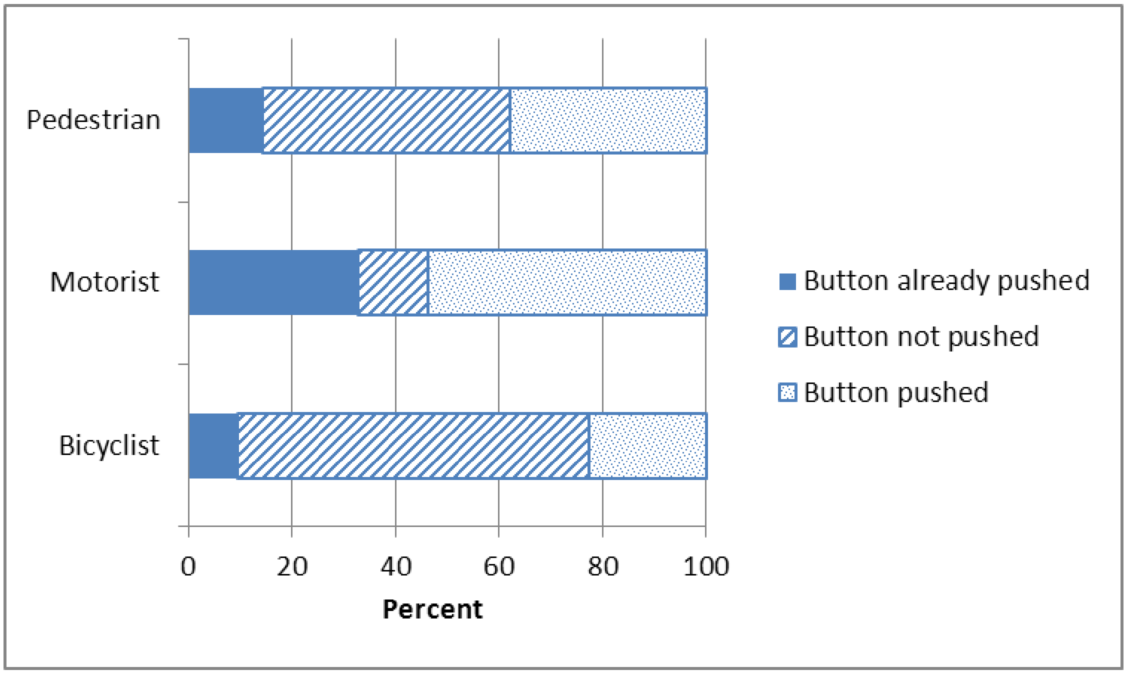

FIGURE 4 Before and after comparisons of yielding as a function of whether or not the call button was pushed.

Avoidance Maneuvers and Conflicts

Interactions between bicyclists, pedestrians, and motorists were coded as either avoidance maneuvers, conflicts, or none. Virtually all of the interactions were avoidance maneuvers (796 before and 1,124 after). There were only two conflicts, and both occurred in the after period. There were no differences in the distributions.

Bicycle, Pedestrian, and Motor Vehicle Responses while Interacting

Bicycles kept moving safely in 2.5 percent of the response interactions before versus 28 percent after, and slowed or stopped pedaling in 30 percent of the response interactions before versus 18 percent after. In addition, bicyclists did not start (i.e., yielded) in 64 percent of the response interactions before and 51 percent after. A chi square test revealed the differences to be statistically significant ($p<.0001$).

Similarly, pedestrians kept moving safely in 17 percent of the response interactions before versus 40 percent after, and slowed in 11 percent of the response interactions before versus 1 percent after. Pedestrians did not start (i.e., yielded) in 67 percent of the response interactions before and 39 percent after. A chi square test revealed the differences to be statistically significant ($p<.0001$).

Motorists had full stops in 2 percent of the interactions before versus 27 percent after when responding to bicyclists and pedestrians. The motorists had no change (i.e., kept moving without yielding) in 98 percent of the interactions in the before period and in 64 percent of the interactions in the after period. A chi square test revealed the differences to be statistically significant ($p<.0001$).

SUMMARY AND DISCUSSION

The installation of the RRFB at the Pinellas Trail crossing with 22 Avenue N was associated with a variety of results. From an analysis of the video data, the following operational results were statistically significant:

- Average trail user delay before starting to cross was reduced from 10.1 seconds in the before period to 5.2 seconds in the after period.
- Bicyclists and pedestrians yielded considerably less, and motorists considerably more, after the installation of the RRFB. Overall, motorist yielding increased from 2 percent before to 35 percent after. When the flasher was activated, motorist yielding was 54 percent.
- The increased yielding by motorists was also reflected in the responses by bicyclists, pedestrians, and motorists when there were interactions.
- In the before period, 82 percent of the trail users were able to cross all the way across the intersection, while 18 percent were trapped in the middle. In the after period, 94 percent of the trail users were able to cross all the way across the intersection, while 6 percent were trapped in the middle.

The results pertaining to the trail users being able to cross completely after the installation of the RRFB are particularly gratifying, as this indicates an improvement in a safety proxy variable. While motorist yielding improved significantly after installation of the RRFB, an issue from the findings is why the motorist yielding was not greater. One factor is whether the button was pushed to activate the flashers. Based on the video analysis in the after period, it is interesting to note that 32 percent of the trail users pushed the button, 49 percent did not, and for 19 percent of the trail users the button had already been pushed. Since almost half of trail users were not pushing the button, the city installed a reminder sign (“PUSH BUTTON TO ACTIVATE BECONS”) to see if this would help (Figure 5.) However, not pushing the button remained a problem in follow-up studies by city staff.

FIGURE 5 Sign to remind users to push the button.

The video showed that bicyclists liked to keep their bicycle moving, rather than stopping next to the push button to activate the flasher. Usually a bicyclist approaching the crossing would slow, observe traffic on the street, and determine if the gap was suitable for crossing. Sometimes a bicyclist would ride in a circling fashion until a gap in traffic appeared. However, when there were long lines of traffic, some of the bicyclists would move over to the push button and activate the flasher. Pedestrians were more likely to push the button than bicyclists.

Another factor relating both to delay and motorist yielding was the way the crossing functioned. In times of busy traffic in the before period, a trail user might have to wait for more than 50 motor vehicles to pass before a suitable gap would be available. Thus, motorists seemed to be in the habit of not yielding. Although this event was not coded, it seemed that more multiple threat situations took place in the before period, where a trail user would cross the first lane with a motorist stopped and then encounter a motorist in the adjacent lane not yielding. Sometimes there was considerable delay after the trail user had reached the middle of the crossing. On one occasion a senior pedestrian crossing in a motorized wheelchair reached the middle of the crossing and a motorist did not yield.

When the button was pushed in the after period, the flashers were activated immediately. However, motor vehicles traveling along the street might be close enough to the crossing (i.e., in the dilemma zone) where stopping to yield would be difficult. These vehicles tended to pass through the crossing while the flashers were operational. Sometimes it appeared that trailing motor vehicles would simply "follow the leader," even though it appeared they had adequate time to stop safely. In many cases it would take 5-10 seconds after the flashers were activated to get motorists to a complete stop, and this is reflected in the delay for the after period. It also appeared that motorists came to recognize that the flasher might be on after trail users had cleared the crossing, and the motorists would proceed on through the crossing without stopping if no users were present. This is a legal maneuver.

Overall, the installation of the RRFB increased the safety of trail users at the crossing through increased motorist yielding and a large reduction in the percentage of users trapped in the middle. However, the device is not fail safe, and communities employing the device, especially at trail crossings, should take note of this. Perhaps additional educational effort would be helpful in (1) increasing the percentage of trail users pushing the button, and (2) increasing motorists' knowledge about the requirement to yield to pedestrians in such crossings. Perhaps of more benefit would be periodic police enforcement operations. These were used in the earlier evaluations of RRFB's installed at pedestrian midblock crossings in St. Petersburg but not in the current study.

The vendor is considering the development of a passive RRFB, where the associated radar would be used to detect those desiring to cross and no button would have to be pushed to activate the flashers. Certain situations would have to be worked out, such as approaching bicyclists who are able to cross within the available gap without need of the flashers, as well as some pedestrians who may stop and rest at the crossing and potentially extend the flashers unnecessarily. If such operational situations could be solved, one would expect the motorist yielding rate to increase with a passive device.

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