BEFORE-AND-AFTER STUDY OF THE EFFECTIVENESS OF RECTANGULAR RAPID-FLASHING BEACONS USED WITH SCHOOL SIGN IN GARLAND, TEXAS

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ABSTRACT

Researchers recently conducted a before-and-after study of driver yielding behavior at a school zone crosswalk in the city of Garland, Texas. City engineers had previously observed that driver compliance with the crosswalk was poor and planned to install overhead and side-mounted rectangular rapid flashing beacons (RRFBs) to improve compliance and facilitate pedestrian crossing maneuvers, and they requested the research team to study the location and evaluate the effectiveness of the device. Researchers observed crossing maneuvers on-site and by video recording during school zone and non-school zone conditions. For non-school zone crossings, they utilized a staged pedestrian protocol, in which members of the research team approached the crossing in a uniform manner and presented conditions in which approaching drivers must make a decision whether to yield to the crossing pedestrian. After analyzing the data before and after installation, researchers concluded that compliance rates of drivers yielding to staged pedestrians improved markedly with the RRFB device in place, from less than 1 percent before installation to approximately 80 percent after. Compliance rates of drivers during school zone periods were similar between the before and after periods, typically between 80 and 100 percent because of the presence of a crossing guard.

BACKGROUND

The city of Garland, Texas, is located approximately 15 miles northeast of downtown Dallas and has an official population of more than 222,000. The City of Garland Department of Transportation (CGDOT) is responsible for providing and maintaining appropriate traffic control throughout the city. Personnel from CGDOT contacted the Texas Transportation Institute (TTI) about planned improvements to a school-related crosswalk at which driver compliance was poor. CGDOT had made plans to install overhead and side-mounted rectangular rapid flashing beacon (RRFBs) at this crosswalk to improve compliance and facilitate pedestrian crossing maneuvers, and they requested the research team to study the location and evaluate the effectiveness of the RRFB device.

Site Description

The crosswalk under consideration is located at the intersection of W. Walnut Street and N. Bullock Drive. An aerial view of the crosswalk prior to installation is shown in Figure 1.

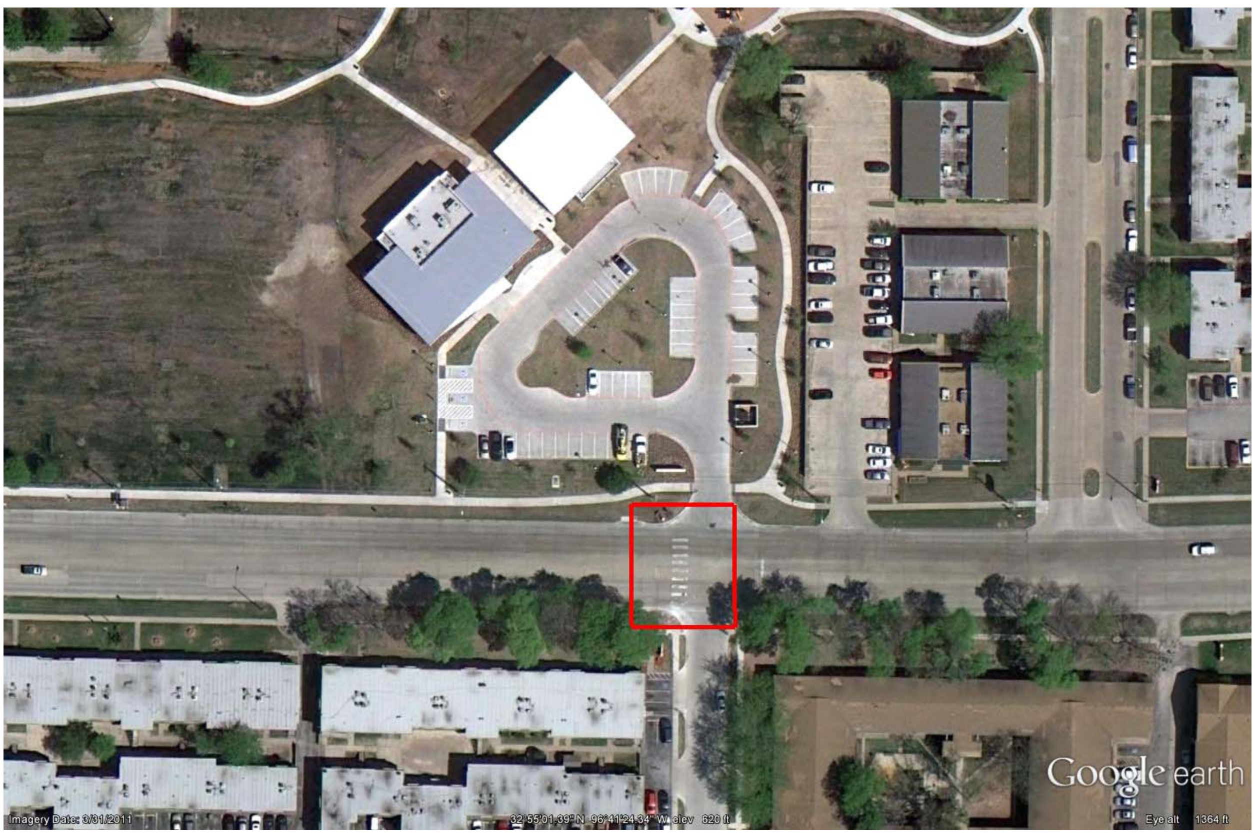

Figure 1. Image of RRFB Study Site. (Image Source: Google Earth™ Mapping Service)

As shown in Figure 1, the study site is officially a T-intersection with a driveway to make four legs at the intersection. Walnut Street is the east-west arterial and Bullock Drive is the south leg of the T. The subject crosswalk runs north-south across Walnut Street on the west side of the intersection. The adjacent development on the south side of Walnut Street consists of apartment complexes, while the north side is the site of a recently opened community center, the driveway of which is aligned with Bullock Drive. Development to the northeast of the intersection consists of small retail outlets and professional offices. Bullock Drive and the community center driveway are stop-controlled.

The subject crosswalk was recently improved as part of the development that opened the community center. Curb ramps were added at either end of the crosswalk where none previously existed, new fluorescent yellow-green School Crosswalk Warning Assembly signs (S1-1 and W16-7L) were posted on either end of the crosswalk, and a pole-and-mast arm assembly was installed on the south end of the crosswalk. The School Crosswalk Warning Assembly sign for eastbound traffic is mounted on the pole of this assembly.

Walnut Street is a four-lane arterial with a continuous center two-way left-turn lane (TWLTL), and Bullock Drive is a two-lane minor collector. The speed limit on Walnut Street is 35 mph. The crosswalk is at the approximate center of a school speed limit zone, which is posted for 20 mph from 6:55 to 8:15 am and 2:55 to 4:00 pm. A crossing guard is stationed at the crosswalk during most of the periods during which the reduced speed limit is in place, approximately 6:55 to 8:00 am and 2:55 to 3:45 pm. The speed limit on Bullock Drive is 30 mph, except for the aforementioned reduced-speed school zone.

An RRFB treatment was proposed to improve driver compliance with the crosswalk on Walnut Street. The treatment consists of a single RRFB assembly installed on the mast arm over the center of the TWLTL for each direction of travel, plus an additional pole-mounted RRFB assembly for each direction of travel on each side of the street. Data were collected at the crosswalk before installation of the RRFB and after installation. An image of the crosswalk prior to RRFB installation is shown in Figure 2.

DATA COLLECTION AND REDUCTION

Video Data Protocol

Members of the research team developed a protocol for collecting and reducing data from the crosswalk study site. A two-person team set up TTI's video trailer at a location on the property of the community center on the north side of Walnut Street, approximately 300 ft west of the crosswalk. The equipment on this video trailer provided a "bird's-eye" view of the crosswalk and traffic on the adjacent street. The dual camera capability of the trailer allowed researchers to record images of activity on Walnut Street for approximately 250 ft on either side of the crosswalk as well as a close-up view of the crosswalk itself. The former camera enabled documentation of vehicular characteristics on the approach and departure to the crosswalk and recorded any nearby pedestrian crossings that did not take place at the crosswalk. The latter camera provided a more detailed view of the activity at the crosswalk itself, showing pedestrians' behavior in approaching the crosswalk, the activity during the presence of the crossing guard, and the presence of any pedestrian-vehicle conflicts. Images from the two cameras were downloaded to a portable digital video recorder (DVR) for playback and archiving in the office. During part of the before-period observations, one camera malfunctioned; researchers focused the single remaining camera onto the close-up view of the crosswalk during that time. Both cameras were fully functional during after-period observations, and both views were used as needed to obtain the data.

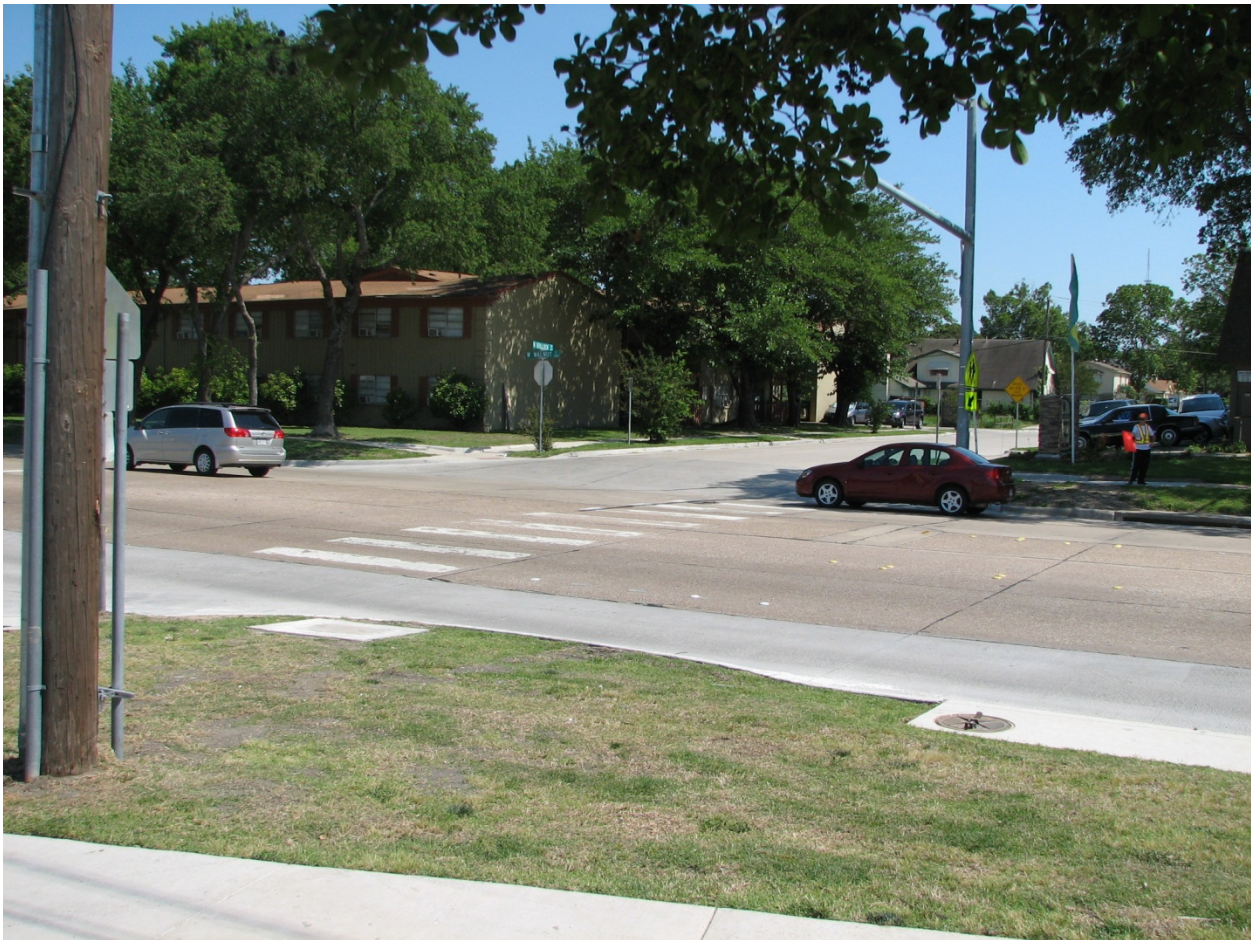

Figure 2. Crosswalk Prior to Installation of RRFB.

Staged Pedestrian Protocol

While recording the video images of the crosswalk activity, researchers also conducted a staged pedestrian study during times in which the crossing guard was not present. Pedestrians who use a crosswalk do so in many different ways; their approach and behavior can vary widely, and, as was the case at this location, the volume of pedestrian traffic may be too low to form a robust sample. A staged pedestrian study can address these issues. Staged pedestrians are members of the research team who approach the crosswalk in the same manner for each crossing maneuver. According to Texas state law (Texas Transportation Code, Section 552.003),
"The operator of a vehicle shall yield the right-of-way to a pedestrian crossing a roadway in a crosswalk if:

(1) no traffic control signal is in place or in operation; and

(2) the pedestrian is:

(A) on the half of the roadway in which the vehicle is traveling; or

(B) approaching so closely from the opposite half of the roadway as to be in danger."

To obtain consistent results that are appropriate for the expected behavior of the driver, crossing pedestrians needed to be "on the half of the roadway" in which vehicles were approaching. Many pedestrians do not do this, choosing to wait completely on the curb or curb ramp until all traffic has passed or yielded. In order to consistently gauge whether drivers would yield at an occupied crosswalk, pedestrians would have to place at least one foot off of the curb into the crosswalk to show intent to cross. Furthermore, the pedestrian would have to approach the crosswalk in such a way that an approaching driver would have sufficient time to respond to the pedestrian's presence and slow down or stop before reaching the crosswalk. Research team members used such a method, approaching the crosswalk as drivers also approached, placing one foot into the crosswalk and then waiting for drivers to yield, or for all traffic to clear, before entering the crosswalk. For the data collection after installation, research team members also activated the RRFB system before placing a foot into the crosswalk.

While one team member served as the staged pedestrian, the other observed and recorded the yielding behavior of drivers on the half of the roadway nearest the start of the crossing maneuver, noting the number of vehicles that yielded or stopped and those that did neither. The two team members periodically changed roles from pedestrian to observer, using the same approach method for each crossing. The team ultimately completed 40 crossing maneuvers, 20 in each direction of travel, during each observation period. For comparison purposes, the team also observed and recorded yielding behavior for crossing maneuvers that took place during the school zone periods when the crossing guard was present.

After the on-site data collection was complete, technicians reviewed the video recordings in the office, to identify all of the observed crossing maneuvers during the observation period and confirm, or revise, the on-site notes and observations recorded at the site. Tasks in the video review included confirming the number of vehicles yielding and not yielding for each pedestrian, identifying each crossing maneuver outside of the crosswalk and noting the associated yielding behavior, and comparing the number of crossing maneuvers before and after installation in both the school zone periods and non-school zone periods.

RESULTS FROM PERIOD BEFORE INSTALLATION

At CGDOT's request, TTI researchers conducted a field study on May 17-18, 2011, to observe and document conditions at the crosswalk prior to installation of the RRFB devices. On-site observations indicated that yielding at this location was very low during periods in which the crossing guard was not present. In fact, researchers identified less than 1 percent of vehicles that yielded during any non-school zone active period. However, yielding was much higher when the crossing guard facilitated pedestrian crossings, between 79 and 100 percent. Table 1 provides a summary of the findings.

Table 1. Yielding Behavior at Crosswalk Before RRFB Installation.

Date	Times	Description	Number of Crossings	Vehicles Yielding		
				Yes	No	Percent
5/17/11	2:55PM - 4:00PM	PM School Zone	15	39	4	91%
5/17/11	4:30PM - 6:00PM	PM Peak	40	1	221	< 1%
5/18/11	6:55AM - 8:15AM	AM School Zone	6	13	0	100%
5/18/11	1:20PM - 2:50PM	Mid-afternoon	40	1	144	< 1%
5/18/11	2:55PM - 4:00PM	PM School Zone	12	22	6	79%

Researchers observed three pedestrians using the crosswalk during non-school zone periods, and there were also 13 crossings that occurred away from the crosswalk during the observation period. This is consistent with the concept that the crosswalk was in place primarily to facilitate school-related traffic, though it was suggested by city engineering staff during the data collection period that the number of pedestrians might increase as more people began to use the community center and as they became accustomed to the presence of the RRFB.

RESULTS FROM PERIOD AFTER INSTALLATION

TTI researchers returned to the site at CGDOT's request to conduct a review of conditions following the installation of the RRFB system. According to CGDOT, the RRFB system was activated on May 27, 2011, and researchers returned to collect data October 6-7, 2011. The time period between installation and data collection allowed drivers to become accustomed to seeing the devices in place, and it ensured that school was in session during data collection. A picture of the installed system at the intersection is shown in Figure 3. RRFB devices were installed curbside on both ends of the crosswalk as well as overhead above the center of the TWLTL. Each of the three displays was two-sided, so that each direction of traffic was shown three RRFB displays. The RRFB system is activated by a pushbutton located under the RRFB device at either end of the crosswalk, as shown in Figure 4; the adjacent supplementary plaque advises pedestrians of the appropriate course of action when using the crosswalk. Yield lines were also added to the lanes on both approaches to the crosswalk; the "sharkstooth" yield markings were placed approximately 25 ft in advance of the crosswalk for eastbound traffic and about 50 ft in advance of the crosswalk for westbound traffic. The marking distance in the westbound direction is greater because the markings were placed just upstream of the driveway to the community center, encouraging drivers to yield prior to entering the intersection and keeping the intersection clear for Bullock Drive and driveway traffic.

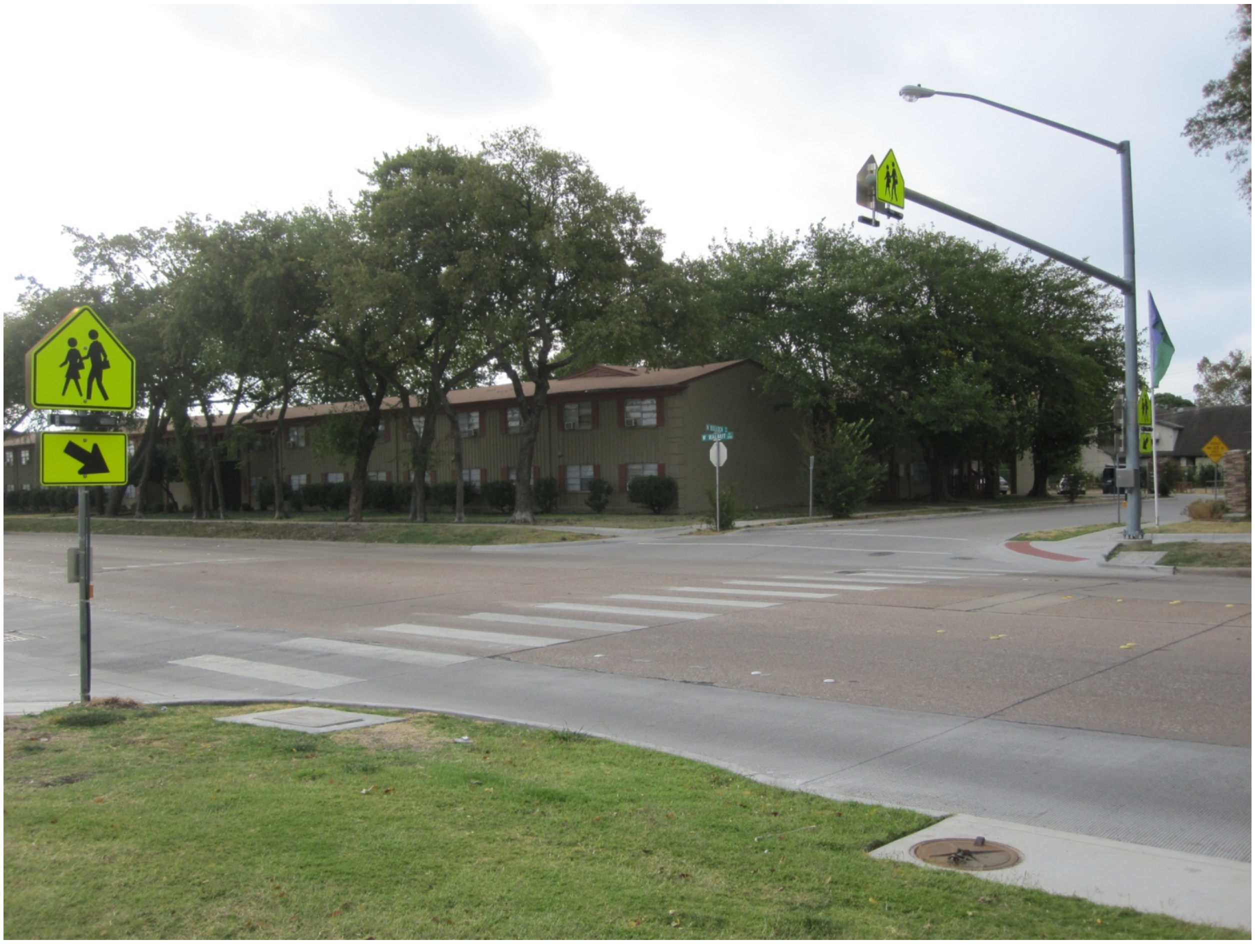

Figure 3. Crosswalk After Installation of RRFB.

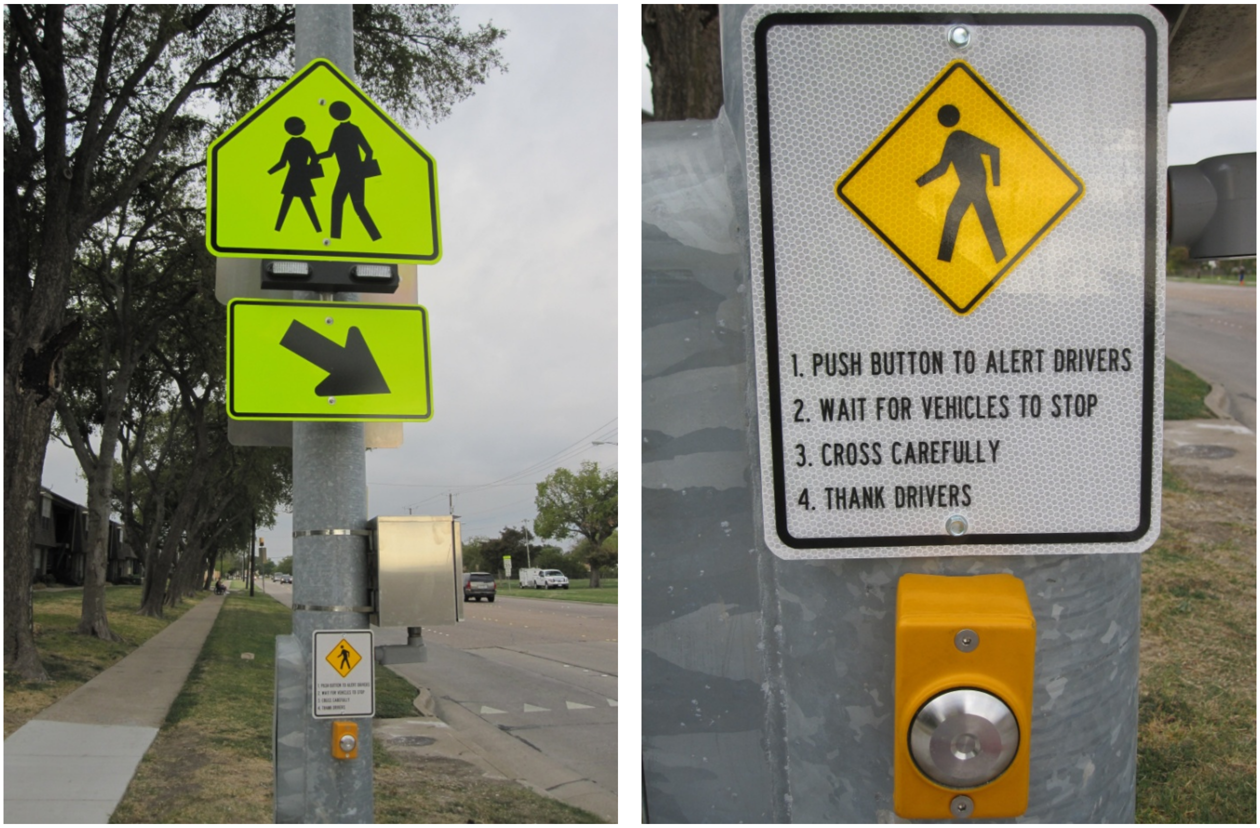

Figure 4. Pedestrian Pushbutton and Instructions for Use of RRFB.

On-site observations indicated that, following installation of the RRFB treatment, yielding at this location was much improved during periods in which the crossing guard was not present. For these crossings with the RRFB installed, staged pedestrians activated the RRFB for each crossing maneuver, as did the crossing guard for all crossings during school zone periods. Table 2 provides a summary of the findings, which indicate that yielding rates in the PM peak and mid-afternoon periods were similar to those in the AM school zone, approximately 80 percent. Yielding rates during the school zone periods when the crossing guard was active were similar to those before installation, between 90 and 100 percent during the afternoon school zone and approximately 80 percent in the morning.

Table 2. Yielding Behavior at Crosswalk After RRFB Installation.

Date	Times	Description	Number of Crossings	Vehicles Yielding		
				Yes	No	Percent
10/6/11	2:55PM - 4:00PM	PM School Zone	13	48	4	92%
10/6/11	4:20PM - 6:00PM	PM Peak	40	110	26	81%
10/7/11	6:55AM - 8:15AM	AM School Zone	7	21	5	81%
10/7/11	1:15PM - 2:45PM	Mid-afternoon	40	111	32	78%
10/7/11	2:55PM - 4:00PM	PM School Zone	11	44	1	98%

Researchers observed a wide variety of reactions to the RRFB devices when activated. Obviously, there were drivers that did not yield, as summarized in Table 2; however, drivers who yielded did so in a number of different ways. The most common manner of yielding was the "textbook" case of a vehicle decelerating and stopping at the yield line until the pedestrian exited the crosswalk. Drivers varied greatly in their deceleration; drivers who were estimated to be traveling near the speed limit were able to decelerate gradually, while faster drivers had to implement near-panic braking to achieve compliance with the yield line. Researchers observed a very small number of vehicles that they anticipated would not yield because of their operating speed, but the drivers were able to stop prior to the crosswalk due to very heavy braking.

It was also somewhat common to see multiple vehicles not yielding for a single crossing pedestrian, adopting a platoon mentality that trailing drivers tended to do what the lead driver did. If a trailing driver saw another driver in close proximity travel through the crosswalk with the RRFB activated, the trailing driver also might not yield. This was particularly the case when those drivers were estimated to be traveling in excess of the speed limit. Because the staged pedestrian protocol dictated that the pedestrian would not fully enter the street until oncoming vehicles had yielded, drivers felt no imminent threat of a crash if they continued through the intersection and therefore could fail to yield to the pedestrian with little subsequent effect.

Conversely, among drivers who did yield, there were also a variety of responses after they decided to yield. Some drivers slowed their speed just enough to provide a gap for the pedestrian, while maintaining most of their free-flow speed. Though this does provide sufficient time to cross, it is a dangerous practice if the driver misjudges the pedestrian's walking speed or if the pedestrian trips or stops to retrieve a dropped item. In the most pedestrian-friendly responses, yielding drivers slowly approached the crosswalk and stopped at the yield line until the RRFB displays went dark, even if the pedestrian had already completed the crossing maneuver and the crosswalk was unoccupied. It is unclear whether these drivers were confused about the appropriate response to the beacons and simply chose to adopt the prudent action of remaining stopped until the beacons deactivated. In some cases, yielding drivers took cues from other drivers, such that if one driver began to enter the intersection after the pedestrian completed the crossing, other drivers would then also start to proceed as well, even if the beacons were still flashing. This suggests that there may be some confusion among drivers about what they should do when they encounter the activated devices; while this may help reduce speeds and affect compliance in the short term, long-term effects are unknown.

Researchers again observed few pedestrians using the crosswalk during non-school zone periods, and there were fewer than 10 crossings that occurred away from the crosswalk during the observation period. This suggests that the RRFB has not necessarily induced higher crossing volumes at the crosswalk. Indeed, researchers noticed several occasions where pedestrians jaywalked near the intersection, even though their continued path suggested that the crosswalk would have been a direct route for them to take if they had they chosen to use it, activate the device, and wait for a gap. An informal discussion with the crossing guard at the site suggested that non-school pedestrians do not like to use the device, perhaps because they think the device is only meant for children. Regardless of any social or psychological stigma attached to the device, it seems that pedestrians at this location are like those in other locations across the country, in that if they identify a gap in traffic that allows a safe crossing, they are motivated to use it, even if it means crossing only a short distance from a crosswalk with an assistive device.

CONCLUSIONS

Installation of RRFB devices at this location appear to have substantially increased the yielding rates of approaching drivers for pedestrians crossing during non-school-zone periods, while the yielding rates when the reduced-speed school zone is active have remained fairly constant. As shown in Table 3, compliance rates of drivers yielding to staged pedestrians improved markedly with the RRFB device in place, from less than 1 percent before installation to approximately 80 percent after. Compliance rates of drivers during school zone periods when a crossing guard is present were similar between the before and after periods, typically about 90 percent. The behavior of approaching drivers varied widely, from making no yielding attempt at all to waiting at an empty crosswalk until the beacons are no longer flashing.

Table 3. Yielding Behavior at Crosswalk Before and After RRFB Installation.

Period	Crossing Type*	Before				After			
		Crossings	Vehicles Yielding			Crossings	Vehicles Yielding		
			Yes	No	Percent		Yes	No	Percent
PM School Zone	Crossing Guard (Non-Staged)	15	39	4	91%	13	48	4	92%
PM Peak	Staged	40	1	221	< 1%	40	110	26	81%
AM School Zone	Crossing Guard (Non-Staged)	6	13	0	100%	7	21	5	81%
Mid-afternoon	Staged	40	1	144	< 1%	40	111	32	78%
PM School Zone	Crossing Guard (Non-Staged)	12	22	6	79%	11	44	1	98%

*Note: The rectangular rapid flashing beacon was activated for each crossing in the After period represented in this table.

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