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THE EFFECTS OF A RECTANGULAR RAPID-FLASHING BEACON ON VEHICLE SPEED

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In 2008, nearly 31% of vehicle fatalities were related to failure to adhere to safe vehicle speeds (National Highway Traffic Safety Administration [NHTSA], 2009). The current study evaluated the effect of a rectangular rapid-flashing beacon (RRFB) triggered by excessive speed on vehicle speed using a combined alternating treatments and reversal design. The percentage of vehicles traveling above 41 mph (66 km per hour) decreased by 20%, and speed distributions showed a shift toward lower speeds during the RRFB condition.

Key words: safety, speeding, speed reduction, traffic

According to the National Highway Traffic Safety Administration (NHTSA), nearly 31% (11,675) of the motor vehicle fatalities in 2008 were related to speeding. Speeding is dangerous because it reduces a driver's ability to steer safely around roadway curves or obstacles in the road and increases the distance required to stop a vehicle (NHTSA, 2009). All of the aforementioned hazards can increase the probability of motor vehicle accidents. In addition to being a cause of motor vehicle accidents in its own right, speeding can also limit or dilute the effectiveness of traffic safety programs designed to reduce other traffic safety risks (e.g., impaired driving) and pedestrian and motorcycle safety initiatives (NHTSA, 2005).

One approach to the problem of speeding is the use of automated systems (Pilkington & Kinra, 2005; Retting & Farmer, 2003). Retting and Farmer assessed the impact of a speed camera enforcement program on traffic speeds in Washington, D.C. A comparison site was selected in Baltimore, Maryland. Speeds at the Washington sites declined by 14%, and the proportion of vehicles traveling more than 10 miles per hour (mph; 16 km per hour, kph) over the speed limit declined by 82% in treated areas. However, a potential limitation of this intervention is that communities may be resistant to cameras due to privacy concerns. McCoy, Bonneson, and Kollbaum (1995) used automated visual feedback to decrease vehicle speeds. The experimenters used radar to detect the speed of approaching vehicles; vehicle speed was then presented to drivers on a digital display panel as their vehicles passed the display device. Average vehicle speed was reduced by 4 to 5 mph (6.4 to 8 kph).

Recently, a new device, referred to as a rectangular rapid-flashing beacon (RRFB), has been demonstrated to be highly effective for improving motorist yielding to pedestrians (Shurbutt, Van Houten, Turner, & Huitema, 2007). Unlike more traditional standard 12-in. round beacons that blink in a slow (one cycle per second) and predictable ("wig-wag" or back-and-forth) pattern, the RRFB is a new type of beacon that makes use of high-intensity light-emitting diodes (LEDs) that blink in a rapid and irregular pattern, similar to what is seen on many modern emergency vehicles. Shurbutt et al. used the RRFB to make the presence of pedestrians more salient, thereby increasing stimulus control over drivers' behavior. The purpose of the current study was to explore the RRFB as a mechanism to reduce speeding. An experimental device designed to trigger the RRFB when vehicles approached at

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excessive speeds was evaluated. If effective in reducing speeds, the RRFB could offer a relatively inexpensive and energy-efficient method for increasing traffic safety.

METHOD

Participants and Setting

Participants for this study were motorists in Mundelein, Illinois, traveling along Lake Street (U.S. Route 45) during daylight hours. U.S. Route 45 is a four-lane divided highway with a grass-covered center median with a sharp curve. As drivers approach the curve, the legal speed limit changes from 45 mph (72.4 kph) to 35 mph (56.3 kph); a speed limit sign signals the change. The area is known for speeding, but police cannot easily pull over drivers because the road has no shoulder.

Response Measurement and Reliability

Vehicle speed at the 35-mph sign was the dependent variable. Data were collected using a modified handheld radar device that was attached by a long cable to a custom triggering device. Human observers were stationed at the 35-mph sign because it gave them the best vantage point from which to observe traffic and trigger the device accurately. The radar device was mounted on a tripod approximately 100 ft (30.5 m) beyond the 35-mph sign. Tall weeds and small trees served to hide the observers from view by oncoming traffic, and the radar device was obscured with camouflage netting. One observer operated the radar as vehicles passed the 35-mph sign while the other entered data into a small laptop computer. Data collection occurred on Saturdays and Sundays during the month of August. A session consisted of 200 trials. A trial consisted of a single vehicle speed observation. Observers typically completed eight to 10 sessions per day, between the hours of 8:00 a.m. and 5:30 p.m. To avoid inadvertently measuring the same vehicle twice or measuring a vehicle at the wrong location, observers measured speeds of lead vehicles only (i.e., the first vehicle in a large group of vehicles). Observers were fully trained prior to the start of the study.

To assess interobserver agreement, two observers collected data independently for 26% of observation sessions. One observer operated the radar device, and then both observers silently recorded the speed displayed on the device. Agreement occurred when both observers recorded the same speed. Interobserver agreement was calculated by dividing the total number of agreements by total observations (agreements plus disagreements) and converting the result into a percentage. Mean interobserver agreement was 99% (range, 96% to 100%).

Procedure

The RRFB, consisting of two small panels of high-intensity LEDs, was mounted along the bottom edge of the 35-mph speed limit sign and was inconspicuous except when flashing. The beacons were directional, so that only approaching vehicles could see them. During baseline, the RRFB did not operate but was present. During the intervention, the RRFB activated only when vehicles traveling at speeds above 41 mph (66 kph) approached within 200 to 300 ft (61 to 91.5 m) of the sign. The activation distance varied depending on vehicle size. For example, smaller trucks, vans, sport utility vehicles, and cars activated the device at a distance of 200 ft (61 m), and larger vehicles like semitrailer trucks and large buses activated it at distances of up to 300 ft (91.5 m). It was visible at a distance of 200 ft. Because traffic at the research site could be heavy during peak times of day, the device was programmed with a mandatory 5-s time-out period after each activation cycle. When the device timed out, it could not be activated by any vehicle, even if that vehicle was exceeding 41 mph. Following the time-out, the device remained turned off until the next vehicle traveling above 41 mph triggered it. This time-out protocol was imple-

mented to prevent the device from running continuously during heavy traffic.

We also conducted basic treatment integrity checks to ensure that the beacon was functioning as designed. These checks involved driving the first author's vehicle past the beacon to verify that it was activating properly and monitoring the device at the beginning of each session to ensure accuracy. The device functioned as designed on 100% of these checks.

Design

A combination alternating treatments and reversal design was used to evaluate the effect of the RRFB on vehicle speed. The experiment began with 13 baseline sessions across one 2-day period to demonstrate stability across day and time. Following baseline, conditions alternated between baseline and RRFB for 14 sessions conducted during the next two weekends. The next phase was comprised of eight RRFB sessions. The study concluded with eight sessions alternating between baseline and RRFB conditions conducted on a Sunday.

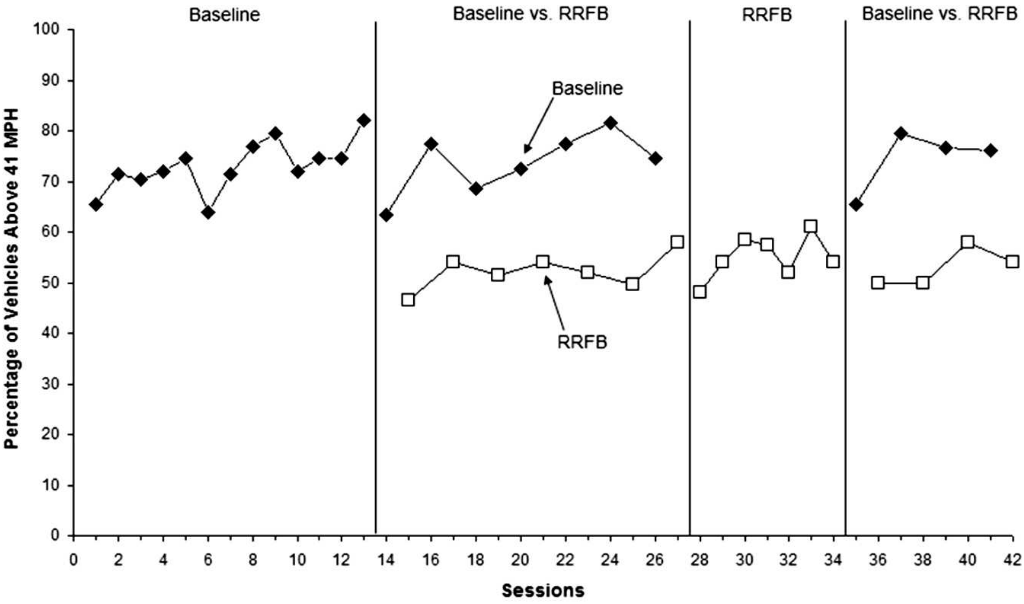
RESULTS AND DISCUSSION

Figure 1 (top) depicts the percentage of vehicles traveling above 41 mph per session. Mean percentage of vehicles traveling above 41 mph during the first baseline phase was 73%. During the second phase, the mean percentage of vehicles traveling above 41 mph during baseline was 74%, and the mean percentage during RRFB conditions was 52%. During the third phase (RRFB only), the mean percentage of vehicles traveling above 41 mph was 55%. During the fourth and final phase, the mean percentage of vehicles traveling above 41 mph during baseline was 74%, and the mean percentage during the RRFB condition was 53%. The mean percentages of vehicles traveling above 41 mph across all baseline and RRFB conditions were 73% and 53%, respectively.

Figure 1 (bottom) depicts speed distribution during both conditions across sessions. This panel displays the combined set of 4,800 baseline trials from a total of 24 sessions and the combined set of 3,600 RRFB trials from a total of 18 sessions. This distribution shows a shift toward lower speeds under the RRFB condition, particularly in the upper end of the distribution.

Although the differences between mean speeds under baseline and RRFB conditions were modest, the intervention produced consistent reductions in mean speed over baseline, with no overlapping data points. Further, it is likely that the simple act of self-monitoring vehicle speeds and reducing gas pedal pressure or applying brake pressure may enable the driver to respond more effectively should emergency stopping be required. Another benefit of the RRFB device is its energy efficiency and cost effectiveness. Because the RRFB runs on solar power, installation is less complex than that for similar beacon installations, and once installed, the device requires very little maintenance.

Shurbutt et al. (2007) found that for the pedestrian-activated RRFB, treatment effects did not greatly diminish over time. However, the pedestrian version of the RRFB allowed the device to operate for each pedestrian, creating a natural one-to-one correlation between onset of the RRFB device and presence of a pedestrian. This configuration may be ideal for maintaining compliance. However, a similar one-to-one correlation between excessive speed and activation of the RRFB could not be arranged in the current study. During early pilot testing, we frequently noted that multiple vehicles, often traveling at different speeds, passed the RRFB unit at nearly the same time. Thus, it is likely that at least some vehicles that were not traveling at excessive speeds were exposed to the RRFB device inadvertently. In addition, no drivers were exposed to the RRFB during the 5-s time-out period after each activation cycle. Future studies should investigate the long-term effectiveness of this intervention.



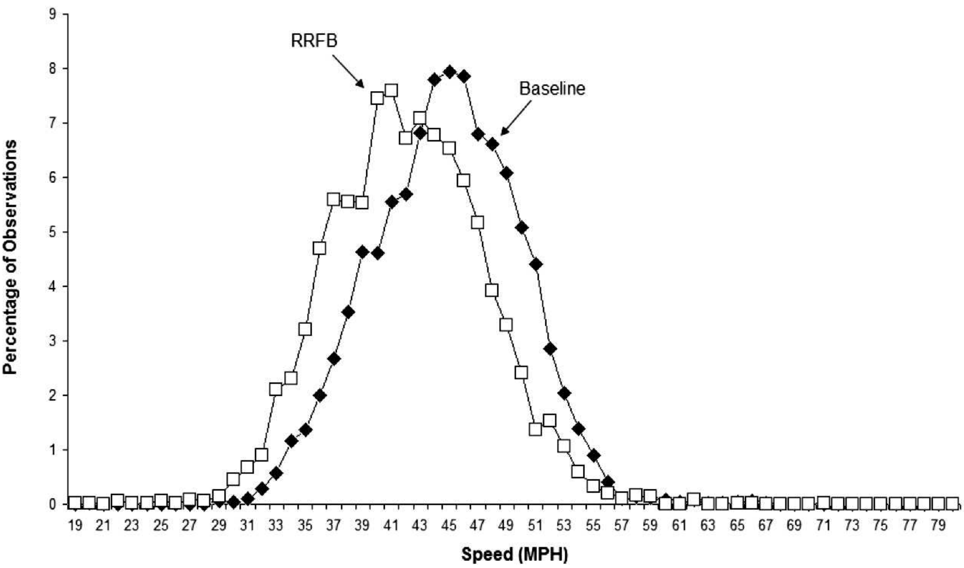


Figure 1. Percentage of vehicles per session traveling in excess of 41 mph across baseline and RRFB conditions (top) and speed distributions (in miles per hour as a percentage of total vehicles; bottom).

It is hypothesized that the RRFB device likely functioned to increase the saliency of the 35-mph sign as an effective discriminative stimulus. The sight of the 35-mph sign set the occasion for the driver to observe the discrepancy between vehicle speed and the posted speed limit. For drivers who had experienced some of the possible consequences of speeding, the sight

of speedometer values greater than the posted speed limit may have served as a conditioned punisher. Drivers responded by modifying their speed to reduce the size of the observed discrepancy, thus avoiding potential aversive consequences.

The study has several limitations. First, the device was set to cycle off for 5 s after it flashed for an initial 5 s. During this period, no vehicles were exposed to the intervention. This means that some drivers traveling at excessive speeds did not contact the intervention. Another limitation was that that the device was activated only when drivers were traveling more than 41 mph in a 35-mph zone. Both of these limitations may have limited the overall speed reductions that were observed. The use of human observers also was expensive and inefficient (slower data collection), and lacked the precision that could be gained by more automated data-collection procedures. Other technologies, such as electronic speed sensors installed directly in the roadway, could be used in future studies to gather data more quickly and to capture data on other important variables more readily, such as traffic density, vehicle types, and road conditions (temperature and moisture level). Some locations, however, are not conducive to these technologies (e.g., some speed sensors will not function properly if placed in close proximity to railroad tracks).

In future studies, experimenters might consider setting the RRFB trigger point to be the same as the actual speed limit rather than 6 mph above the posted limit. Future studies could also explore applications of the RRFB in other settings where speed reduction is required (e.g., construction zones, school zones, etc.). The device could also be used on other types of signs to increase vigilance and awareness. For example, unsafe speed was also involved in 54% of fatal crashes that occurred under snowy conditions and 59% of fatal crashes that occurred under icy conditions in 2008 (NHTSA, 2009). If combined with moisture and temperature sensors, the device might be used to alert drivers to slippery road conditions.

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