THE EFFECTS OF AN ELECTRONIC FEEDBACK SIGN ON SPEEDING

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Although a handful of experiments have utilized indirect feedback in attempts to reduce speeding on roadways, fewer experiments have utilized direct feedback as a means to reduce incidences of speeding. The current study evaluated the effects of direct and individualized feedback provided by a large electronic feedback sign that displayed the speed of oncoming vehicles as they approached the sign along the roadways of a college campus. The effects of the sign were evaluated using a non-simultaneous multiple baseline experimental design employing two control conditions and intervention phase. Each condition was implemented at three sites on the college campus. The results showed that intervention produced significant decreases in both measures of vehicle speeds at each site, relative to measures collected during both control conditions.
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CHAPTER 1
INTRODUCTION

Automobiles traveling along roadways at excessive speeds is as old a problem as the automobile itself (www.wikipedia.org 22 Feb. 2006 [A]). Van Houten (1980) noted that "data obtained from many American States show that as vehicles speed varies from the mean traffic speed, the chance of an accident increases." Vehicles exceeding speed limits present problems across a variety of roadways, from major freeways to neighborhood roads to school zones. Although very few studies have investigated speeding interventions in school zones, the presence of many pedestrians and increased density of traffic often occurring near school areas suggest that maintaining appropriate vehicle speed in school zones should be an important focus of intervention. For example, in 2002 there were 662 speeding tickets issued by the University of North Texas Police Department (Josey, 2005).

A wide range of interventions have been employed to decrease the speed of vehicles, including the use of “traffic calming devices” (www.Wikipedia.org, 22 Feb. 2006 [B]). Examples of traffic calming devices including speed humps, traffic circles, roundabouts, speed feedback signs, as well as warning signs to alert drivers when they are exceeding the speed limit.

Most studies investigating the use of traffic calming strategies have focused on the use of feedback signs (e.g., Ragnarson & Bjorgvinsson, 1991; Roque & Roberts, 1989; Van Houten, Nau, & Marini, 1980; Van Houten & Nau, 1981; Van Houten & Nau, 1983). In a classic study that initiated a series of replications, Van Houten et al. (1980) evaluated the effects of public posting of speeds on an urban highway. The experiment
took place at a location on the highway where the speed limit changed from 80km/hour to 50km/hour upon entering a residential area. The experimenters used a Mark IV-A Radar Speedalyzer that was hidden from the view of traffic to calculate the speed of passing traffic. Vehicle speeds were compared across several conditions during this study, including baselines in which (a) no sign was present, (b) the sign was present but covered, and (c) the sign was present and uncovered but no numbers were posted; and feedback conditions in which the sign was erected at the location of the speed limit change (i.e., at the same point in the roadway where the first 50km speed limit sign was located) and the mean percentage of vehicles speeding either (a) the previous day or (b) the previous week was posted. Results showed that posted feedback produced decreases in the percentages of vehicles exceeding the speed limit. The presence of the sign alone did not reduce speeding, however, and daily feedback was more effective than weekly feedback.

Roque and Roberts (1989) conducted procedures similar to those described by Van Houten et al. (1980). As was the case in the Van Houten study, the speed limit on this roadway changed prior to the area where the study was conducted. Data were collected through the use of induction loops embedded within the highway. Conditions included baselines in which the sign was present but covered and interventions in which either accurate or inaccurate (the number of vehicles not speeding was higher than the actual numbers recorded) daily feedback was presented. Results did not replicate those observed in the Van Houten et al study, showing little or no change from baseline to intervention conditions. The authors suggest that one possibility for the disparity between these outcomes may be due to a “chain reaction” effect on crowded roadways,
in which several vehicles may slow down in response to a single vehicle’s reduction in speed ahead (Van Houten et al. noted the possibility that some drivers in their study may have decreased their speed in response to seeing brake lights on the cars preceding them on the roadway). This effect would, of course, be more pronounced in dense traffic, and the site of the Roque and Roberts study had “a lower traffic flow” than in the Van Houten et al investigation; Roque and Roberts suggested that the effects obtained by Van Houten et al. may have been, in part, “amplified” due to this chain effect.

Ragnarsson and Bjorgvinsson (1991) addressed the potential influence of a chain effect by including criteria for excluding potential participant vehicles from their study. These researchers compared the effects of a single sign containing information about the percentage of drivers speeding alone and combined with a sign showing “best record so far” (p. 54) versus baselines in which no signs were present. Vehicles were excluded if more than one vehicle was traveling on the road at the point of speed detection, if an exceptionally slow vehicle (construction vehicle) was present, or if the speed detection radar device displayed the speed of the vehicle traveling in the opposite direction of those vehicles included in the study. Results showed a decrease in the average speed during the feedback phases compared with baseline phases (no significant difference was observed between the single and double posting conditions). Given that the exclusion criteria should have reduced the influence of brake lights or congested traffic, the changes in speeding obtained in this study appear to be related to the public posting rather than a chain reaction.
The results of these and a handful of additional studies on the effects of posting delayed feedback about traffic speeding patterns (e.g., Hunt, 1984; Martin & McClure, 1984; Van Houten et al., 1985) have produced inconsistent findings. Whereas some studies have shown significant decreases in speeding in the presence of signs displaying data on the speed of vehicles on the previous day or week (e.g., Ragnarsson & Bjorgvinsson, 1991; Van Houten, Nau, & Marini, 1980; Van Houten & Nau, 1981), others have shown no such effects (e.g., Hunt, 1984; Martin & McClure, 1984; Roque & Roberts, 1989). A possible reason for this failure to show robust effects of feedback may be that the feedback provided in these studies was too delayed and/or nonspecific (Daniels, 2004). In each of the studies previously described the feedback that was presented was based on measures obtained from other vehicles and was not presented until one day or one week after measures were taken. Two published studies have been conducted that evaluated the effectiveness of immediate, specific feedback on speeding.

Hunter, Bundy, and David (1976) evaluated the effectiveness of a visual speed indicator (VSI). The VSI was a 1.524 X 2.438 m traffic sign and logic system that was placed beside a 2-lane rural highway (speed limit, 55 mph). The VSI displayed the speed of passing vehicles, as well as a warning to “SLOW DOWN” when vehicles were traveling in excess of the posted speed limit. The experimenters collected data using induction loops embedded within the roadway. Data were recorded at three locations along the roadway. The first location was 2 miles upstream of the VSI, the second location was alongside the VSI, and the third location was 2 miles downstream of the VSI. The results showed that the activated sign produced significant reductions in the
mean speed and the percentage of traffic speeding at the location of the sign; however, these effects dissipated by the time the vehicles reached the third (downstream) recording site. The outcomes of this study suggest that, when used on rural highways, the effects of the VSI were immediate but temporary.

Casey and Lund (1993) assessed the effects of a mobile roadside speedometer on the speed of traffic. The roadside speedometer included a static sign showing the current speed limit posted above an electronic display on which the speed of oncoming vehicles was displayed. Measures were taken at three points along the roadside (upstream, alongside and downstream). In the first phase of this study the effects of the device, the effects of the roadside speedometer were evaluated at 5 sites, showing significant reductions in average vehicle speed at each site, especially for vehicles traveling at higher speeds. In the second phase, the sign was deployed on varying schedules and associated patterns of police enforcement, with results indicating that when the mobile speedometer was deployed continuously the effect on speed diminished over time, but when the mobile speedometer was deployed with enforcement (police presence) the effect lasted well into the third week of the study.

During the third phase, the researchers conducted observations between 9:00am and 11:00am in five school zones. One baseline observation period was conducted on a weekday at each school zone, and one intervention observation was repeated on the same weekday, one week later. Results showed decreases in average speeds at each site; however, average speeds remained above the posted speed limit at each site.

Of previous research on the effectiveness of feedback to decrease speeding, only Ragnarsson and Bjorgvinsson (1991) included exclusion criteria to address
potentially confounding variables such as a chain reaction effect. Their study was also the only study to utilize handheld speed recording devices to record data on participant speeds, which permitted the investigators to identify specific vehicles for inclusion or exclusion from the study. To date, no study has used exclusion criteria to evaluate the effects of immediate, specific feedback on vehicle speeds. Finally, although Casey and Lund (1993) evaluated the effectiveness of immediate and specific feedback in school zones, only one measure was collected before and during intervention, limiting an account of the effects of the intervention over time. The present study evaluated the effectiveness of immediate, specific feedback in a University school zone. Potential confounds were addressed by establishing exclusion criteria, collecting data using operator-held speed detection devices, and evaluating the effects of the intervention using a multiple-baseline across settings experimental design.
GENERAL METHOD

Materials, Experimental Design, Participants, and Setting

Materials

The materials used during this project were a hand-held ATR Stalker Radar Gun® (Stalker Corp, Plano Texas), supplied and calibrated by the University of North Texas Police Department, a speed awareness monitor (electronic speed feedback sign), pens, data sheets, and clipboards. The radar gun used microwaves to calculate the speed of moving vehicles. Manufacturer specifications indicate that the radar gun is accurate at +/- 1 mph while at a stationary position. Measures of target vehicle speed were taken from approximately 9 to 18 meters. The angle from which measures were taken was no greater than 45 degrees.

The electronic speed feedback sign was provided by the University of North Texas parking office. The sign stood 2.34 meters tall by 1.65 meters wide. Attached to the sign was a sign displaying the speed limit (20 miles per hour). The feedback portion of the sign used a battery-powered internal radar detector attached to a LED feedback box. The radar detector detected vehicle speeds in the same manner as the radar gun and displayed the speed of oncoming vehicles on the LED display. The LED display was .86 meters wide by .832 meters high (see appendix) with a display visibility of 335.28 meters (speed awareness monitor specification sheet).

Experimental Design

The experimental design of this study was a 3-component (baseline, sign present but not activated, sign present and operational), non-simultaneous multiple baseline
The experiment was conducted sequentially across sites 1, 2, and 3, respectively. A strength of the non-simultaneous multiple baseline design is that, because the amount of time each condition is in effect varies across baselines, any potential effects of the time spent in each condition can be detected. A limitation of this design is that it does not control for the potential for coincidental events that occur simultaneously with changes in conditions. All experimental phases were completed at each location before initiating baseline procedures at subsequent locations.

During Baseline the speed of target vehicles was recorded at specific locations along the roadway. During a Baseline 2 the speed of target vehicles was recorded at the same locations with the electronic speed feedback sign present but not activated. During Treatment the speed of target vehicles was recorded with the electronic speed feedback sign in place and activated. Data were collected in the same manner throughout all phases.

Participants and Settings

The participants in this study were drivers who passed through each of the three sites and met the inclusion criteria (see Table 1). The three sites used in this study were located on exterior roadways of a college campus. The sites were chosen in collaboration with campus police and choices were based on reports of frequent speeding from the police as well as the experimenter’s personal history suggesting that automobiles frequently traveled at speeds in excess of limits at those sites. At each of the sites speed limit signs were posted on the right side of the road prior to the point at which observations were conducted. The speed limit sign was within 30 meters of
location where the target vehicle speed was taken (see Illustrations 1, 2, and 3 for detailed diagrams of each location).

Site 1 was located at the intersection of Hickory Street and Avenue B (see Illustration 1). Vehicles traveling east in the right hand lane on Hickory Street (a two-lane, one-way road located on the north side of the campus) were eligible for inclusion in this study. At the time of this study, a construction site was located on Hickory Street prior to the area where vehicles were selected for inclusion. However, observations of the site by the primary investigators and personnel from the University of North Texas Police Department revealed no disruption in traffic flow. Because a stop light and pedestrian crosswalk were located at the east end of the target zone in Site 1, a set of exclusion criteria specific to this site were developed to reduce the potential influence of these variables. For example, data were not collected if the traffic light was red or yellow or if stopped automobiles remained present at the intersection after the traffic light turned to green. A comprehensive list of exclusion criteria across all sites is shown in Table 1.

Site 2 was located on North Texas Boulevard, north of Eagle Drive (see Illustration 2). Vehicles traveling north in either lane on North Texas Boulevard (a four-lane, two-way road located on the west side of the campus) were eligible for inclusion in the study. This location was chosen based on observations of the site by the primary investigators and reports of speeding traffic by personnel from the University of North Texas Police Department. Because a pedestrian crosswalk was located at the front of the target zone, and a commuter parking lot was located along the west side of the target zone in Site 2, a set of exclusion criteria specific to this site were developed to
reduce the potential influence of these variables. For example, data were not collected if pedestrians were present in the crosswalk, if a vehicle turned into the parking lot in front of a target vehicle, or if a target vehicle turned into the parking lot. A comprehensive list of exclusion criteria across all sites is shown in Table 1.

Site 3 was located at the intersection of Welch Street and West Mulberry Street (see Illustration 3). Vehicles traveling south in the right lane on Welch Street (a four-lane, two-way road with traffic traveling both north and south on the east side of campus) were eligible for inclusion in the study. This location was chosen based on reports of speeding traffic by personnel from the University of North Texas Police Department. Because an intersection and a crosswalk were located within the target zone in Site 3, a set of exclusion criteria specific to this site were developed to reduce the potential influence of these variables. For example, data were not collected if pedestrians were present in the crosswalk or if a vehicle traveling on Mulberry turned onto Welch in front of a target vehicle. A comprehensive list of exclusion criteria across all sites is shown in Table 1.

Data Collection

Prior to initiating data collection at each site the experimenters visually inspected the target zone for any obstructions. The target zone at each site began at the point on the roadway at which target vehicles were selected for measurement (see Figures 1, 2, and 3 for detailed diagrams of target zones across all sites) based on the exclusion criteria. The end of the target zone was a point on the roadway beyond the location of the electronic speed feedback sign and was the final point at each site where
inclusion/exclusion criteria were applied to determine eligibility of vehicles for inclusion in the study. That is, for each vehicle that was determined to be eligible as it entered the target zone, exclusion criteria were applied throughout the target zone. For example, if a vehicle was identified as potentially eligible for speed measurement as it entered the target zone but an exclusion event occurred as it traversed the zone (e.g., a pedestrian entered a crosswalk), then no measures were recorded for that vehicle.

Data collectors were stationed in discrete locations on the side of the roadway at each site. Observation sessions started when the primary data collector indicated that the first vehicle that passed through the target zone without meeting exclusion criteria would be the first target vehicle. The primary data collector collected measures on target vehicles by pointing the radar gun at the vehicle and depressing the trigger for 2 s when the target vehicle reached the spot on the roadway designated for measurement. After the first measure was taken, vehicles that entered the target zone 30 s after the previous target vehicle left the target zone were eligible for measurement. If a potentially eligible target vehicle met any of the exclusion criteria while passing through the target zone, the clock was reset from the moment of exclusion, and the next vehicle that entered the target zone after 30 s elapsed was monitored for eligibility. Sessions continued until 20 measures had been recorded.

Data were collected by recording the speed measurement from the radar detector onto a data sheet. During interobserver agreement sessions, the primary data collector recorded the speed of the target vehicle from the radar detector and immediately turned the display screen of the radar detector toward a second, independent, data collector. The second data collector recorded the speed displayed
on the radar gun on a separate data sheet. Interobserver agreement data were collected during 50% of sessions at Site 1, 44% of sessions at Site 2, and 35% of sessions at Site 3. Agreement coefficients were calculated by summing the number of identical measures, dividing the result by the number of total measures, and multiplying the result by 100. Interobserver agreement for vehicle speed averaged 99.2% at site 1 (range = 95% - 100%), 96.5% at site 2 (range = 95% - 100%), and 99% at site 3 (range = 95% - 100%).
RESULTS

Outcomes of this study are displayed in Figures 1-7. Figure 1 displays the percentage of vehicles speeding (i.e., traveling at or in excess of 21 mph) per session across the three locations; Figure 2 displays the mean percentages of vehicles speeding; Figure 3 displays the mean speed at which vehicles traveled across each phase and location; and Figures 4-6 display distributions of vehicle speed measures across phases (within figures) and locations (across figures). These data are graphically displayed as percentages of measures across 2-mph speed bins. For each data point, the number of speed measures falling into the designated bin was divided by the total number of measures taken within the designated condition, and the results were multiplied by 100 to obtain a percentage score. Thus, the sum of measures comprising each distribution curve equals 100. Results will be described for each location below.

Site 1

The top panel of figure 1 displays percentages of drivers speeding (i.e., observed to be traveling at 21 mph or more) at Site 1. During Baselines 1 and 2 the percentages of vehicles speeding were high and relatively stable, with all measures falling above 75%. During Intervention the percentage of vehicles speeding fell to below 45% with only a single measure exceeding 45% (the first observation session). The mean percentages of vehicles speeding across experimental conditions are presented in figure 2. Percentages of vehicles speeding at Site 1 were 88.75% during Baseline, 84% during Baseline 2, and 45.71% during Intervention. The mean speeds of vehicles
across experimental conditions are presented in figure 3. Mean speeds at Site 1 were 24.26 mph during Baseline, 22.96 mph during Baseline 2, and 21.87 mph during Intervention. Figure 4 displays the distribution of percentage scores across conditions in 2 mph bins at site 2. The distribution graph shows the greatest percentages of vehicles were traveling between 21-22 mph across all conditions, with 22.5%, 26.25%, and 33.37% of measures falling into this bin during Baseline 1, Baseline 2, and Intervention, respectively. Although the peak of the distributions were within the 21-22 mph bin across conditions at this site, baseline distributions were skewed to the right, with 87% of vehicles traveling in excess of 20 mph during Baseline 1 and 82.5% traveling in excess of 20 mph during Baseline 2. By contrast, only 43.74% of vehicles were observed to be traveling in excess of 20 mph during Intervention. Visual inspection shows that the shape of this curve is steeper, or more “peaked” than those generated from baseline data, and is skewed to the left of the peak (i.e., the majority of measures fall at or below 21 mph).

Site 2

The middle panel of Figure 1 displays percentages of drivers speeding at Site 2. During Baselines 1 and 2 percentage scores were generally lower and showed relatively greater variability than at Site 1, with a range between 0% and 55%. During Intervention percentages of vehicles speeding became less variable and fell to below 5%. The mean percentages of vehicles speeding across experimental conditions are presented in figure 2. Percentages of vehicles speeding at Site 2 were 25.56% during Baseline, 25% during Baseline 2, and 1.66% during Intervention. The mean speeds of
vehicles across experimental conditions are presented in figure 3. Mean speeds at Site 2 were 18.35 mph during Baseline, 18 mph during Baseline 2, and 16.19 mph during Intervention. Figure 5 displays the distribution of percentage scores across conditions in 2 mph bins at site 2. The distribution graph shows that the greatest percentage of vehicles (26.8%) were traveling between 17-18 mph during Baselines 1 and 2, and the greatest percentage of vehicles (30.8%) were traveling between 15-16 mph during Intervention. Although the peaks of the distributions were below the 19-20 mph bin across conditions at this site, baseline distributions were skewed to the right, with 24.36% of the vehicles traveling in excess of 20 mph during Baseline 1 and 25.58% traveling in excess of 20 mph during Baseline 2. By contrast, only 1.66% of vehicles were observed to be traveling in excess of 20 mph during Intervention. Visual inspection shows that the shape of curve for Intervention data is steeper, or more “peaked” than those generated from baseline data, the distribution of measures for the Intervention shifted to the left when compared to Baselines 1 and 2.

Site 3

The bottom panel of figure 1 displays percentages of drivers speeding at Site 3. During Baselines 1 and 2 percentage scores were variable, with a range of 5% to 60%. During Intervention the percentage of vehicles speeding fell to below 25%, with a range of 0% to 25%. The mean percentages of vehicles speeding across experimental conditions are presented in figure 2. Percentages of vehicles speeding were 44.295% during Baseline 1, 32.92% during Baseline 2, and 9.5% during Intervention. The mean speeds of vehicles across experimental conditions are presented in figure 3. The mean
speed of vehicles across experimental conditions was 20.10 mph during Baseline 1, 19 mph during Baseline 2, and 17.41 mph during Intervention. Figure 6 displays the distribution of percentage scores across conditions in 2 mph bins at site 3. The distribution graph shows that the greatest percentage of vehicles (23.5%) were traveling between 19-20 mph during Baseline 1, the greatest percentage of vehicles (22.5%) were traveling between 17-18 mph during Baseline 2, and the greatest percentage of vehicles (36.5%) were traveling between 17-18 mph during Intervention. Although the peaks of the distributions were below 20 mph across conditions at this site, baseline distributions were skewed to the right, with 44.4% of the vehicles traveling in excess of 20 mph during Baseline 1 and 32.7% traveling in excess of 20 mph during Baseline 2. By contrast, only 9.5% of vehicles were observed to be traveling in excess of 20 mph during Intervention. Visual inspection shows that the shape of this curve is steeper, or more “peaked” than those generated from baseline data.
DISCUSSION

The results of this study showed that an electronic feedback sign produced decreases in the percentages of vehicles speeding and average vehicle speeds along three roadways of a university campus. In addition, distributions of the percentages of vehicle measures across 2-mph bins showed that the shape of distributions changed from Baseline to Intervention. Baseline conditions generated curves that were relatively flat and somewhat skewed to the right of the peak; by contrast, Intervention produced higher peaks, tighter curves, and a general shift toward the left, relative to Baseline curves. These outcomes were consistent across the three sites of the study.

These outcomes indicate that the use of an electronic speed feedback sign was an effective tool for managing the speed of traffic at these locations on a college campus. The results of this study are consistent with those of previous research showing that feedback about traffic speed can reduce speeding (e.g., Ragnarsson & Bjorgvinsson, 1991; Van Houten, Nau, & Marini, 1980; Van Houten & Nau, 1981). Whereas most previous work in this area utilized delayed and imprecise feedback, the current study evaluated the effects of immediate feedback on the speed of participant vehicles, replicating and extending procedures described by Hunter, Bundy, and David (1976) and Casey and Lund (1993), who also evaluated the effects of immediate feedback on vehicle speeds.

The current study implemented several controls that were not present in the previous studies on the effects of immediate and specific feedback. By taking data on individual vehicle speeds via user-operated devices the experimenters were able to implement exclusion criteria that increased the confidence with which attribution of
changes in speed to the electronic speed feedback sign, and nothing else, could be made. For example, because a radar-based measurement device was used in the current study, a 30-s delay between measures was implemented in order to reduce the potential effects of the prevalent use of radar detectors. This delay reduced the likelihood that vehicles upstream from the data collection site would detect and respond to the radar gun, potentially causing reactivity. Furthermore, several exclusion criteria were developed to address the potential influence of a “chain reaction” (Van Houten et al., 1980), or the influence that reductions in speed by one driver can have over a group of “upstream” drivers. For example, by excluding potential participant vehicles when another vehicle was located in front of the target vehicle within the target zone, when other vehicles turned onto the roadway within the target zone, or when vehicles were parking at the side of the roadway, the influence of traffic ahead of target vehicles was minimized. Other potential sources of influence also were addressed using exclusions. For example, vehicles were excluded from the study if pedestrians, bicycles, or animals were present in the target zone; if university vehicles were present; if police vehicles were visible (even outside of the target zone); or if emergency sirens were audible, thereby decreasing the likelihood of contamination of the data by these variables. A potential limitation of this study is that data collectors may have been visible to some participants. Therefore, the speed at which some participants traveled may have been affected to the extent that participants observed data collectors with the radar gun; however because this was constant throughout all phases of this study, the effects of this potential confound would presumably be distributed equally across conditions and, therefore, would not represent a serious threat to the internal validity.
An interesting outcome of this study was that at sites 2 and 3, the average speed during Baselines was at or below 20 mph. Given that the posted speed limit was 20 mph it was unclear what affect the electronic speed feedback sign would have. At each of those sites, however, the activated sign produced decreases in the average speed, as well as decreases in the percentage of drivers speeding. As revealed in the percentage distributions, these outcomes appear to have resulted from decreased instances of vehicles traveling at speeds above the posted limit, rather than a general decrease in speed. For example, whereas the distribution curves for these sites show significant overlap to the left of peaks across conditions, values to the right of the peaks are consistently lower during intervention than during either Baselines. Thus, for these sites, the intervention appeared to have a greater effect at higher speeds, similar to outcomes reported by Van Houten, 1980, Van Houten and Nau, 1981, Casey and Lund, 1993.

Higher values across both the percent of vehicles speeding as well as the average speed were observed across conditions at Site 1, relative to other sites. Although the variables responsible for this difference are unclear, there are several possibilities. First, whereas there was a history of the presence of the electronic speed feedback sign at sites 2 and 3, the sign had not previously been placed at Site 1. Interestingly, the results of Intervention at Site 1 show a decreasing trend in speeding, consistent with this account. Alternatively, it is possible that Site 1 was associated with a history of less enforcement of speeding violations, although no data are available to assess this interpretation.
Accounts of the behavioral mechanisms responsible for the efficacy of the electronic speed feedback sign include a potential association between such devices and the presence of police. This account suggests that the sign may acquire conditioned aversive properties for drivers who have had a history in which the presence of speed detection devices was paired with an increased likelihood of punishment (e.g., being pulled over and receiving a speeding ticket). By this account, drivers would decrease their speed at the point at which the device was visible in order to avoid a possible punisher (i.e. speeding tickets) associated with speeding.

Throughout the current study university law enforcement officers patrolled all sites. During all sessions with the exception of session number 20 at Site 3, there were no police vehicles stationed at any of the sites while the sessions were being conducted. If a police officer was stationed at a site the session was either terminated or paused until the police vehicle left the site. During session 20 at site three, a police vehicle was stationed in a parking lot in a location that was out of the visual site of any vehicles passing by. This session was not terminated or paused because the data collectors did not notice the police officer until the end of the session. Based on the data, there was no observable influence on the speed of drivers. The overall police presence may have been a factor in this study; however, this is highly unlikely based on the occurrence of several high speed measures during Baseline across all sites. In any case, because police presence was distributed relatively equally across conditions, any impact of police presence does not affect interpretations about the effects of the feedback sign.
The design for this study was a non-simultaneous multiple baseline across three sites. This was chosen because, at the onset of the study, the university police department agreed to suspend ticketing at each individual site during observation periods at that site (because this agreement was not adequately communicated to patrolling officers, tickets continued to be written throughout the study). Based on this agreement, it would not have been possible to conduct sessions at all sites simultaneously. A potential drawback to this design is that it is not possible to determine if the presence of the electronic speed feedback sign at one site had an impact on the speed of drivers at any of the other locations. Future studies employing simultaneous observation periods across sites would help clarify this potential effect.

There are several potential directions for future research regarding the use of electronic speed feedback signs to manage the speed of traffic. For example, replicating the current procedures with a reversal at each of the locations could help identify the enduring effects of the sign (if any) following its removal. Further investigations of similar interventions on high traffic streets, highways, and other roads would help to clarify the conditions under which feedback signs are more or less effective. Other research might measure speed prior to the sign, at the location of the sign, and at various points beyond the sign in order to determine the points at which the effects of the sign begin to affect driver behavior, as well as the distance at which those effects dissipate.
Table 1

List of Exclusions

- The target vehicle stops at the crosswalk
- Pedestrians at the crosswalk
- Pedestrians crossing the crosswalk
- Pedestrians walking on the sidewalk
- Pedestrians or bicyclist on the road within the target zone
- A vehicle in front of the target vehicle within the target zone
- The target vehicle turns while within the target zone
- The target vehicles stops while within the target zone
- The target vehicle changes lanes while in the target zone
- An animal on the road within the target zone
- A yellow or red light at the time of taking the speed of a vehicle
- A vehicles is turning onto the roadway while at the time of taking the target
  vehicle speed
- A vehicle is parking on the side of the roadway in the target zone
- A vehicle stopped at the crosswalk or stoplight within the target zone
- A vehicle is driving next to the target vehicle
- A UNT vehicle of any kind is in the target zone
- A vehicle is in front of the target vehicle
- A vehicle is turning out of a construction site before entering the target zone
- A vehicle is in front of the target vehicle before entering the target zone
- A police vehicle is on the roadway before or after the target zone
- There are audible emergency vehicle sirens
- If the primary data collector recognizes the vehicle as belonging to an
  acquaintance
Figure 1. Site 1.
Figure 2. Site 2

Posted Speed Limit

Location where target vehicles were selected for inclusion

Placement of electronic speed feedback sign

Second floor balcony

Coliseum

Data collectors

Fire Hydrant

Location where speed of vehicle was taken

Parking lot exit

Parking lot enter
Figure 3. Site 3.
Figure 4. Percent of vehicles traveling at or above 21 mph.
Figure 5. Mean percent of vehicles traveling at or above 21 mph.
Figure 6. Mean speed per phase.
Figure 7. Mean distribution in 2 mph bins at Site 1.
Figure 8. Mean distribution of speeds in 2 mph bins at Site 2.
Figure 9. Mean distribution of speeds in 2 mph bins at Site 3.
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