Traffic Speed Control by Speed Feedback

Sanford M. Reece Jr.
Western Michigan University

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TRAFFIC SPEED CONTROL
BY SPEED FEEDBACK

by
Sanford M. Reece, Jr.

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Master of Arts

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I want to thank Mr. Bruce Evans who gave me many hours of help in the design and construction of equipment used in this project.

I want to thank the members of the Portage, Michigan City Council who graciously considered and approved my request to conduct an experiment on the streets of their city.

I am grateful to Chief George E. Von Behren of the Portage Police Department for providing the radar equipment used in my experiment and the training in the use of that equipment.

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Sanford M. Reece, Jr.
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INTRODUCTION

The role of the police officer in the process of traffic law enforcement is to warn, serve citations on, or arrest offenders. The purpose of these actions is to induce voluntary compliance with traffic regulations (Weston, 1968).

This role, however, requires the police officer attend only to the law violator. He has little or no contact with the individual who obeys traffic regulations. In fact, the police officer often pays little attention to the majority of traffic violations he observes. An example of this fact is the procedure employed by most police officers when they use radar to control traffic speed.

Few, if any, police departments make it a policy to stop and cite all drivers who exceed a posted speed limit. There is, then, a difference between the posted speed limit and the speed a vehicle must register on a radar unit to warrant a warning or citation for the driver. Usually this difference is set by police department policy and ranges between 4 and 10 miles per hour.

At any radar site, then, the police officer does not attend to the drivers who drive at or below the speed limit, and he does not attend to those drivers who exceed the speed limit but do not exceed the criterion speed to warrant a citation. There are two results of this procedure which bear some consideration.

First, as Chief George E. Von Behren of the Portage, Michigan Police Department suggests, this creates what he calls a
"reverse limbo effect." As the limbo dancer learns how low he can go, the driver learns how high he can go. According to Chief Von Behren, most drivers exceed posted speed limits by a few miles per hour knowing they are not likely to be stopped and cited.

The second result of this procedure is that it makes the police officer a punishing agent. Once the police officer has stopped a traffic violator his only options are to warn, cite, or arrest the individual. In this case, the only individuals to come in contact with the police officer see him as an administrator of punishment.

Weston emphasizes that "The primary purpose of traffic enforcement is to induce voluntary compliance with reasonable traffic regulations." (Weston, 1968). Enforcement alone, however, cannot achieve this obviously desirable goal. In two studies conducted at Northwestern University, State Police patrols, and consequently enforcement of traffic regulations, were substantially increased to examine the effect of increased enforcement on several driver behaviors. Radar units were concealed along roadways where increased enforcement had been instituted and also along several roadway sections where increased enforcement had not been instituted. These studies determined that increased enforcement does not reduce average driver speed or the percent of drivers exceeding the posted speed limit (Shumate, 1958, 1959).
The present experiment was designed and conducted to explore an alternative to the usually punitive techniques used by most police officers to control traffic speed. This experiment utilized a speed feedback system which measured automobile speed with a radar unit and displayed that speed in lighted digits on a sign clearly visible to the automobile driver. The sign legend stated the posted speed limit and the automobile speed.

The purpose of this study was to evaluate traffic speed as a function of presenting to drivers a display of their speed as measured by radar. The independent variable in this experiment was the display of radar measured speed. The dependent variable was traffic speed. Two measures of traffic speed were considered: average traffic speed (ATS) (determined by adding all speeds recorded in a time period and dividing that sum by the number of speeds recorded in that time period), and the percent of drivers in a time period that exceeded the posted speed limit (determined by dividing the number of speeds recorded in a time period that exceeded the speed limit by the number of speeds recorded in that time period and multiplying the quotient by 100).

Two recently completed studies on a four mile section of highway in North Carolina utilized a speed feedback system similar to the system in this present experiment to inform passing drivers of their speed. That study utilized automated speed measuring equipment two miles before, at, and two miles past the speed feedback sign. The essential analysis of the North Carolina study
was to evaluate the change in driver speed two miles past a single exposure to the speed feedback system (Bundy and Hunter, 1975 & Note 1).

In the present study it was hypothesized that the use of such a speed feedback system, repeated during a specific time period over several days, would reduce the ATS and percent of drivers exceeding the speed limit during that time period. The desired effect was not necessarily to reduce the speed of drivers some distance down the road after one exposure to the speed feedback sign, but, through multiple exposures to the speed feedback system, show a reduced speed effect over several days and show some residual effect after the speed feedback sign is removed from a particular site.
METHOD

Subjects

The subjects in this experiment were drivers who passed, in one direction, three roadside sites in Portage, Michigan during each experimental session. The crucial subjects were the multiple exposure subjects, those who passed the sites more than once during each phase. The multiple exposure subjects made up a portion of the total group on which data were obtained. Data were not taken on two subjects. One was a police officer responding to an emergency call; the other was a driver who stopped at a site to discharge a passenger. Data were taken on all other subjects. A total of 2662 drivers passed the sites during the experiment, 645 at one site, 831 at another, and 1186 at the third.

Apparatus

The two primary pieces of equipment were a Stephenson Radar Speedalyzer, Model IV-A, manufactured by Stephenson Corporation, Eatontown, New Jersey, and a speed feedback sign (SFS) which was designed and built by the experimenter. The Stephenson Radar Speedalyzer is a radar unit used by many police departments to measure automobile traffic speed. It consists of two pieces, an antenna, and the control and indicator unit. The antenna can be mounted on the outside or the inside of the operating vehicle. The control
and indicator unit has a speed indicator meter which is calibrated in miles per hour from zero to 120. There is a meter stop switch attached to the control and indicator unit by a three foot cable. When the meter stop switch is turned to the "ON" position, the needle on the speed indicator meter will stop and hold its position until the meter stop switch is turned to the "OFF" position. The antenna is attached to the control and indicator unit by a six foot cable. Power is provided to the entire unit by a cable that plugs into the cigarette lighter receptacle of the operating vehicle. A picture of the radar control and indicator unit appears in Figure 1, page 7.

The speed feedback sign (SFS) was rectangular, 64 inches high and 24 inches wide (See Figure 2, page 8). The top thirty inches of the sign was a standard 35 mile per hour speed limit sign with four inch black letters and ten inch black numerals on a white background. Immediately below the speed limit sign was a 14 inch high and 24 inch wide sign with four inch black letters on a white background. The legend of this portion of the sign read "YOUR SPEED," the word "YOUR" above the word "SPEED" and both centered on the sign. The bottom 20 inches of the sign was painted flat black. On the black background were mounted 48 light units which, when lighted in the appropriate combination, displayed any two digit number from 00 to 99. Each digit was 18 inches high and ten inches wide.
Figure 1 - Radar Control and Indicator Unit, and Sign Control Box.
Figure 2 - Speed Feedback Sign (SFS).
Each light unit was a 14.4 volt, 0.24 amp bulb mounted on a two inch diameter base and covered with a two inch diameter amber lens. Each light unit was set in a flat black metal tube 2.125 inches in diameter and 2.5 inches deep.

Power for the lights was provided from the battery of the operating vehicle through a ten foot cable that connected the sign to the sign control box (See Figure 1, page 7). The sign control box was 18 inches by 12 inches by 2.75 inches. On it were mounted controlling switches for the lighted digits on the sign. The lighted digits were controlled by 20 SPST toggle switches arranged in two vertical columns, ten switches in each column. The switches in each column corresponded to the numerals one through nine in ascending order up each column with the number zero at the top of each column. The left column of switches controlled the tens on the sign and the right column of switches controlled the units on the sign. For example, to display the number 35 on the sign, the third switch from the bottom in the left column and the fifth switch from the bottom in the right column would be turned to the "ON" position.

The operating vehicle for the experiment was a 1975 Maroon Chevrolet Vega station wagon. The SFS when used was mounted vertically on the left half of the rear bumper. Mounted in this fashion, the bottom edge of the SFS was approximately 22 inches above the ground and the entire sign was visible to drivers of vehicles approaching the rear of the operating vehicle.
When the SFS was in use the radar antenna was mounted outside the operating vehicle on the left side window, aimed to the rear. When the SFS was not in use the radar antenna was mounted inside the operating vehicle, aimed out the rear window.

Procedure

Three roadside sites were selected in the town of Portage, Michigan using the following criteria: 1. All sites would be on two lane roadway (one lane in each direction), 2. The experimenter could legally park a vehicle on the road shoulder with a clear view of all approaching traffic for at least 500 feet to the rear of the parked vehicle, 3. The speed limit would be the same at all sites and not change at least 1/4 mile before nor 1/4 past each site, and 4. The sites would be located on major cross streets where regular commuter traffic could be expected from day to day. The sites selected were on Romence Road approximately 1/4 mile west of Westnedge Avenue, Milham Road approximately 1/4 mile east of Oakland Avenue, and Romence Road approximately 1/4 mile east of Oakland Avenue. Those sites were called Romence East, Milham, and Romence West, respectively. At the Romence East and Romence West sites eastbound traffic was observed, and at the Milham site westbound traffic was observed.

The time period 6:45 a.m. to 8:00 a.m. was estimated by the experimenter to be a time period when regular commuter traffic could be expected past each site. Prior to starting the experiment,
the experimenter parked at each site from 6:45 a.m. to 7:00 a.m.,
7:15 a.m. to 7:30 a.m., and 7:45 a.m. to 8:00 a.m. and counted the
number of vehicles that passed each site during each time block.
Except for the Milham site from 6:45 a.m. to 7:00 a.m., each site
was sampled during each time block for five days. The Milham site
in the 6:45 a.m. to 7:00 a.m. block was sampled for three days.
This sampling was done to estimate the average number of vehicles
that passed each site during each time block (Sample N).

The six possible combinations of sites and time blocks were
then compared to determine which site would be sampled in each time
block during the experiment. The combination of sites and time
blocks was selected that yielded the most nearly equal Sample N
for all three sites. The combination selected was: Romence East,
6:45 a.m. to 7:00 a.m.; Milham, 7:15 a.m. to 7:30 a.m.; and Ro-
mence West, 7:45 a.m. to 8:00 a.m.

Experimental sessions were conducted at each site, Monday
through Friday for five weeks. There were two exceptions to this
schedule. A session was not conducted at the Romence East site
(6:45 a.m. to 7:00 a.m.) on the third day of the first week due to
the late arrival of the equipment. No sessions were conducted at
any site on the fifth day of the fourth week since it was a national
holiday and normal commuter traffic would not be present.

The experiment consisted of a pre-experimental phase and five
experimental phases. The pre-experimental phase was conducted to
estimate the amount of repeat commuter traffic passing each site
during the experimental sessions. This phase consisted of five
sessions at each site. As each vehicle passed the site, the exper­
imenter read the license plate number and recorded it orally on a
portable tape recorder. After all three sessions each day, the
recorded license numbers were transcribed to a data book for a
permanent record. These data were used to estimate the percent of
vehicles that passed each site more than once in a week during the
daily 15 minute sessions.

During experimental sessions 1 through 5 the speed of each
vehicle passing each site during the sessions was measured and
recorded. At each site an anomaly in the roadway paving was
selected as a speed mark. Each speed mark was selected so that each
vehicle passed over the speed mark before it passed the experimen­
ter's parked vehicle. At the Romence East and Milham sites the
speed mark was 250 feet to the rear of the experimenter's vehicle;
at the Romence West site the speed mark was 210 feet to the rear of
the experimenter's vehicle.

As a single vehicle approached the site the speed of the
vehicle registered on the speed indicator meter. When the vehicle
passed over the speed mark the meter stop switch was turned to the
"ON" position and the speed of the vehicle as it passed over the
speed mark was "locked" on the meter. Speeds were recorded both by
recording them orally on a portable tape recorder and writing them
on a data sheet on a clipboard. After the speed was recorded the
meter stop switch was turned to the "OFF" position and the meter
again registered the speed of approaching traffic.
When more than one vehicle approached the site the speed of the nearest vehicle would register on the speed indicator meter. If the distance between vehicles was greater than the distance from the experimenter's vehicle to the speed mark, each vehicle could be treated as a single vehicle. If the distance between approaching vehicles was less than the distance between the experimenter's vehicle and the speed mark, the first vehicle was treated as a single vehicle and the speed of any following vehicle or vehicles was "locked" on the meter and recorded as the vehicle preceding it passed the experimenter's vehicle.

When the SFS was used the experimenter had to manipulate the switches on the sign control box so the meter stop switch was not utilized and vehicle speeds were recorded orally only. Speeds recorded orally only were later transcribed to a data book for a permanent record.

When using the SFS, as an approaching vehicle passed over the speed mark the speed indicator reading was recorded orally on the portable tape recorder and the switches on the sign control box were turned on to display on the SFS the speed that was read on the meter and recorded. The speed was displayed on the SFS until the subject vehicle passed the experimenter's vehicle. If the speed of the approaching vehicle changed between the speed mark and the experimenter's vehicle, the switches on the sign control box were manipulated to display the new speed but the change in speed was not recorded.
If, while using the SFS, the distance between approaching vehicles was less than the distance between the experimenter's vehicle and the speed mark, the following vehicle's speed was recorded and displayed on the SFS as the preceding vehicle passed the experimenter's vehicle.

During phase 1 (sessions 1 through 5) the SFS was not used at any site. Traffic speed was measured and recorded at each site.

During phase 2 (sessions 6 through 10) the SFS was used at the Milham site. The SFS was not used at the Romence East or Romence West sites. Traffic speed was measured and recorded at all three sites.

During phase 3 (sessions 11 through 15) the SFS was used at the Romence East site. The SFS was not used at the Milham or Romence West sites. Traffic speed was measured and recorded at all three sites.

During phase 4 (sessions 16 through 21) the SFS was not used at any site. Traffic speeds were measured and recorded at all three sites.

During phase 5 (sessions 22, 23, and 24) the SFS was used at the Romence East site. The SFS was not used at the Milham or Romence West sites. Traffic speeds were measured and recorded at all three sites.

After 24 experimental sessions the experiment was terminated.
RESULTS

Data collected at all three sites during session 15 were not included in the analysis. The weather that day was very foggy, adding a complicating variable that could not be controlled. The thickness of the fog and its apparent effect on traffic speed were variable from site to site and during sessions at each site. All other data collected were used in the analysis.

Repeat Traffic

The number and percent of the five session total of drivers passing each site two or more sessions is presented in Table 1.

<table>
<thead>
<tr>
<th>5 Session Total</th>
<th>Number And Percent Passing All 5 Sessions</th>
<th>Number And Percent Passing 4 or More Sessions</th>
<th>Number And Percent Passing 3 or More Sessions</th>
<th>Number And Percent Passing 2 or More Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romence East</td>
<td>70</td>
<td>2</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>2.8%</td>
<td>8.5%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Milham</td>
<td>131</td>
<td>5</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>3.8%</td>
<td>6.8%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Romence West</td>
<td>136</td>
<td>2</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>1.4%</td>
<td>6.6%</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

Table 1 - Number and percent of drivers passing each site two or more sessions during the pre-experimental phase.
Average Speeds

See Figure 3, page 17, for a graph of average traffic speeds during sessions and phases at each site.

During phases 1 and 2 the speed feedback sign (SFS) was not used at the Romence East site. The average traffic speed (ATS) during those phases at that site was 38.02 miles per hour. During phase 3 the SFS was used at the Romence East site. The ATS for that phase at that site was 35.87 miles per hour. During phase 4 the SFS was not used at the Romence East site. The ATS for that phase at that site was 36.46 miles per hour. During phase 5 the SFS was again used at the Romence East site. The ATS for that phase at that site was 35.02 miles per hour.

At the Milham site the SFS was not used during phase 1. The ATS for that phase at that site was 33.95 miles per hour. During phase 2 the SFS was used at the Milham site. The ATS for that phase at that site was 33.20 miles per hour. During phases 3, 4, and 5 the SFS was not used at the Milham site. At the Milham site the ATS for phases 3, 4, and 5 was 34.48 miles per hour, 34.44 miles per hour, and 34.25 miles per hour, respectively.

At the Romence West site the SFS was not used during any phase. The overall ATS for all sessions at the Romence West site was 36.49 miles per hour. The ATS for any one phase did not vary from that overall ATS by more than 0.62 miles per hour.
FIGURE 3 - AVERAGE TRAFFIC SPEED FOR SESSIONS AND PHASES.
Percent of Drivers Exceeding the Speed Limit

For a graph of the percent of drivers exceeding the speed limit during each phase at each site, see Figure 4, page 19.

At the Romence East site the SFS was not used during phases 1 and 2. At that site during phases 1 and 2 the percent of drivers exceeding the speed limit was 74.3% and 72.7%, respectively. At the Romence East site the SFS was used during phase 3. At that site during phase 3 the percent of drivers exceeding the speed limit was 41.3%. At the Romence East site during phase 4 the SFS was not used. At that site during phase 4 the percent of drivers exceeding the speed limit was 56.7%. At the Romence East site during phase 5 the SFS was again used. At that site during phase 5 the percent of drivers exceeding the speed limit was 35.8%.

At the Milham site during phase 1 the SFS was not used. At that site during phase 1 the percent of drivers exceeding the speed limit was 31.4%. At the Milham site during phase 2 the SFS was used. At that site during phase 2 the percent of drivers exceeding the speed limit was 32.0%. At the Milham site during phases 3, 4, and 5 the SFS was not used. At that site during phases 3, 4, and 5 the percent of drivers exceeding the speed limit was 48.3%, 42.0%, and 42.7%, respectively.

At the Romence West site the SFS was not used during any phase. At that site during all phases the percent of drivers exceeding the speed limit was 59.9%. At that site the percent of
FIGURE 4 - PERCENT OF DRIVERS EXCEEDING THE SPEED LIMIT DURING EACH PHASE AT EACH SITE.
drivers exceeding the speed limit during individual phases ranged from 50.0% during phase 1 to 67.2% during phase 4.
DISCUSSION

The results support the original hypothesis that the speed feedback system can help reduce ATS and the percent of drivers who exceed the posted speed limit. At both the Romence East and Milham sites the ATS during the phases when the SFS was used were lower than the ATS during phases when the SFS was not used. One would not expect the effect to be large or to persist long if the ATS at a site before the use of the SFS was below the posted speed limit. Such was the case at the Milham site.

However, at the Romence East site the ATS was more than 3 miles per hour above the posted speed limit prior to the use of the SFS. When the SFS was initially used at that site, the ATS dropped to within 1 mile per hour of the posted speed limit. That effect appeared to persist for the first four sessions immediately following the removal of the SFS. After those four sessions there was a three day break in data collection due to a three day holiday weekend. The two sessions following the three day weekend the ATS at the Romence East site was back up to the level observed prior to the use of the SFS. When the SFS was again used at the Romence East site the ATS dropped to its lowest point at that site during the experiment.

At the Romence East site the percent of drivers exceeding the speed limit changed in a direction corresponding to the changes in ATS. That is, initially high, dropping when the SFS was used,
increasing when the SFS was removed, and dropping again when the SFS was again introduced. At the Milham site a corresponding change was not seen in the percent of drivers exceeding the speed limit. This does not seem surprising, however, since the percent of drivers exceeding the speed limit was relatively low initially at the Milham site.

Overall, it appears the degree of the effect of a speed feedback system and the persistence of that effect are at least partially a function of the initial ATS prior to using this system.

Since the original hypothesis assumed the effect of the speed feedback system would be seen in drivers who have had more than one exposure to the SFS, one would not expect to see the effect the first session the SFS was used. The results support this assumption (See Figure 3). Session 6 at the Milham site was the first session the SFS was used at that site. That session the ATS was at the level of the ATS in the previous phase. Sessions 7, 8, 9, and 10 the ATS was at a lower level at the Milham site. Session 11 at the Romence East site was the first session the SFS was used at that site. That session the ATS was at a level similar to the ATS for the previous phase. During sessions 12, 13, and 14 the ATS at the Romence East site were substantially lower.

The next experiment of this type should be designed to evaluate more precisely the effect of multiple exposure to a speed feedback system. This might be accomplished by recording vehicle speeds and license plate numbers throughout the experiment. This
might be done by incorporating a video recorder with the other apparatus to record the license plate numbers, or a second experimenter could be utilized for this purpose.

If this were accomplished, the experiment could be conducted at one site, using a repeated measures design on one group of subjects. Using one site would allow the experimenter to conduct longer daily sessions. Intuitively, one would expect a higher percent of repeat traffic with longer daily sessions.

Also, it may be to the advantage of the next experimenter to arrange a less obtrusive system of speed measurement. While conducting this experiment several subjects stopped to ask about the radar unit in the experimenter's vehicle. One individual called the police department to complain about the unofficial cars being used as "speed traps." One individual stopped and asked the experimenter to calibrate his speedometer.

More importantly, it is not known to what degree the radar unit and the experimenter's vehicle were conditioned stimuli that slowed traffic by their presence. Radar units are most often associated with police traffic control. The experimenter's vehicle was associated with a sign that prompted traffic to slow down. One of the studies at Northwestern University (Shumate, 1959) got around this problem by concealing the radar unit in a roadside mailbox.

If further research in this area supports the general findings of this experiment, a system of speed feedback can offer
several advantages to local and State police agencies. Average traffic speed and the percent of drivers that exceed the speed limit can be reduced with a relatively inexpensive system. The system could be portable and mounted on a radar squad car, or it could be a permanent device mounted at a roadside site and operated automatically.

Most importantly, a speed feedback system offers the police officer a new method of traffic speed control. A method that attends to all drivers, and does not merely catch the worst offenders, punish them, and let the rest go.
APPENDIX

The method of sampling in this experiment did not produce purely random and independent samples. Neither was the technique one of a repeated measure on one or more groups. The sampling fell somewhere in between, with some subjects measured repeatedly over time, and some subjects measured just once in the experiment. The method of this experiment did not allow the experimenter to discriminate between those measures that were one time samples and those that were measures of subjects previously sampled.

Also, the speed of one vehicle could not always be said to be independent of the speed of other vehicles. On a two lane roadway, where passing is not practical, the first car in a line of cars will determine the upper speed all cars in line may attain.

With these facts in mind, the following statistical analysis is presented.

Since the primary statistic in the experiment was the average speed of traffic, a two-tailed t-test was used to estimate the significance of the difference between several group means. Formulas and tables for these computations were obtained from a basic statistics text book by Glass and Stanley (1970).

The groups analyzed were made up of subjects who passed the Romence East and Milham sites during the phases listed in Table 2, page 26.
Table 2 - Groupings of subjects for statistical analysis.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Romence East</th>
<th>Milham</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>Phases 1 &amp; 2</td>
<td>Phase 1</td>
</tr>
<tr>
<td>Group 3</td>
<td>Phase 3</td>
<td>Phase 2</td>
</tr>
<tr>
<td></td>
<td>Phase 5</td>
<td></td>
</tr>
</tbody>
</table>

Group 1 in each case consists of those subjects that passed the site prior to the use of the SFS at that site. Groups 2 and 3 consisted of subjects passing the site while the SFS was being used at that site.

The t-test analysis of the Milham site data did not show a significant difference (alpha equal to or less than .05) between Group 1 and Group 2 means.

The t-test analysis of the Romence East site data showed a significant difference (alpha less than .001) between Group 1 and Group 2 means and also between Group 1 and Group 3 means.
REFERENCES


REFERENCE NOTES