ABSTRACT

This study was designed to determine whether the display of a warning sign designating a speed check zone can affect the speed characteristics of drivers traveling through the zone. Two test sections of highway, one 20 miles long and the other 12 miles long, were chosen which reflected a difference in roadway type. Five speed monitoring stations were established for each test site in order to determine the speed of traffic along the road. Speed data were gathered under three specified conditions for both directions of traffic: (a) warning signs were displayed between the first and second speed measuring stations in addition to the prominent display of a patrol car on the shoulder of the road at the middle station, (b) the same as (a) but no sign was displayed, and (c) where neither sign nor patrol car was displayed.

Several methods were used to analyze the data, including an examination of the mean speeds, variances, cumulative speed distributions, and percentage of vehicles exceeding the posted speed limit for each condition. The data reflected an alteration in the motorists' driving performance due to the display of the patrol car, as evidenced by a lower mean speed, smaller percentage of cars exceeding the legal speed limit, and more compact cumulative speed distributions. This was observed only at the sites where the patrol car was displayed. It was hypothesized that the speed check zone sign would extend the "halo effect" associated with the display of a patrol car. The "halo effect" is characterized by drivers typically correcting any unlawful actions for approximately one mile after observing a patrol vehicle, then reverting to their previous actions. However, there was no apparent reaction to the display of the speed check zone sign, and the "halo effect" was not extended. Therefore, it was concluded that the speed check zone sign had very little, if any, effect upon the drivers

INTRODUCTION

Enforcement represents but one area in which highway safety concepts are tested. In recent years, various approaches have been implemented that deal with this concept. The concept of selective traffic enforcement, when hazardous locations or groups of drivers are more closely monitored, has received widespread attention. This project was not concerned with selective enforcement per se, but rather with an innovative signing approach coupled with some selective enforcement ingredients.

This report is the result of a joint effort by the University of North Carolina Highway Safety Research Center (HSRC) and the North Carolina State Highway Patrol to evaluate a new method used by the patrol in its continuing attempts to reduce the number of accidents on North Carolina highways by reducing the number of drivers violating the legal speed limit. Specifically, this study was designed to determine if, and how, the display of a warning sign designating a speed check zone can affect the speed characteristics of drivers traveling through the zone.

In an attempt to make the most effective and economical use of law enforcement personnel and equipment to reduce the speed of North Carolina drivers 1,900 signs designating "SPEED CHECK ZONE" were issued to North Carolina Highway Patrolmen at a rate of two signs per trooper. These rectangular-shaped, black and white signs were to be periodically and selectively attached to the sign post beneath already existing roadside signs which were usually of the type that indicated the speed limit (see Figure 1). The signs were displayed on highways in high traffic collision frequency locations for the purpose of informing the motoring public that their speed was to be checked and their driving observed by one or more patrolmen during the following 15-20 miles. In conjunction with this,

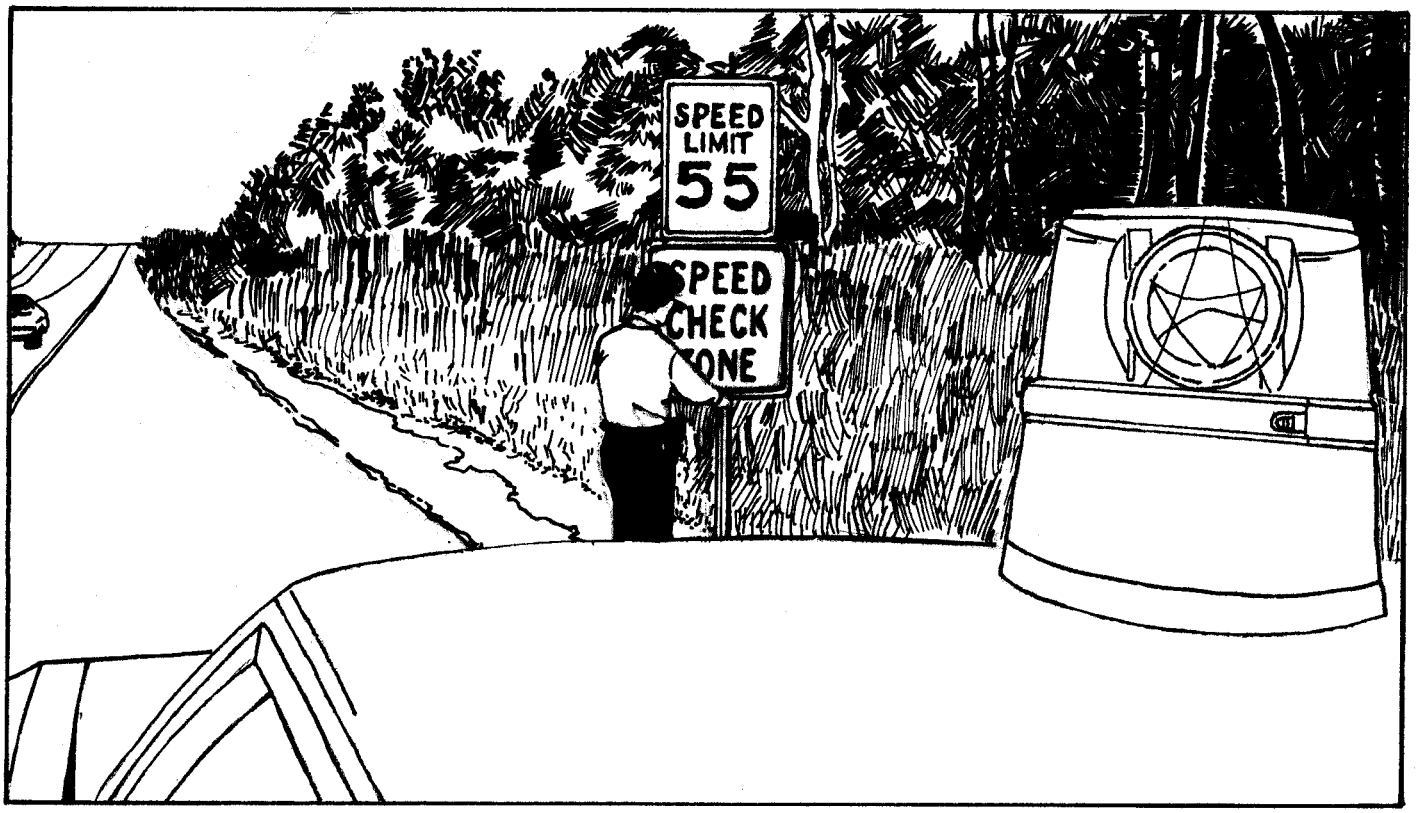


Figure 1. Typical placement of a Speed Check Zone Sign.

provisions were made for extensive news coverage to introduce motorists to the concept and purpose of the program. Among other things, the public was to be informed of the purpose of the program, a description of the signs, and the manner in which the signs were to be used. The news articles also indicated that the signs were never to be used unless troopers were actually on patrol, and that there was no limit to the number of troopers to be assigned to a specific speed check zone. These troopers would employ a variety of speed monitoring devices, including stationary radar, VASCAR, and moving radar.

Theoretically, this procedure was designed to extend the so-called "halo effect" associated with an enforcement symbol such as a patrol vehicle. The halo effect is said to occur after a motorist encounters such a symbol and then corrects his faulty or unlawful driving. It is said that usually a driver will maintain his careful driving manner for about one mile and then revert to his normal driving behavior. It was theorized that if the driving public in North Carolina came to associate the speed check zone sign with the presence of one or more highway patrolmen within a 15-20 mile roadway segment, the halo effect would be extended to this distance. This study was designed to determine whether this effect was achieved. Specifically, two questions were to be answered:

1. Has the North Carolina motoring public come to associate the speed check zone signs with the presence of highway patrol cars so that a halo effect is associated with these signs?

2. If the speed check zone signs are associated with a halo effect, has this effect been extended to a distance of 15-20 miles?

In an earlier HSRC study, Council (1970) attempted to determine the halo effect associated with the presence of highway patrol cars, and whether the effect differed if the patrol car was moving or stationary. In the stationary car condition, individual vehicles were identified and tracked as

they came through the test route, a two-lane rural highway. A patrol vehicle was conspicuously displayed on the side of the roadway at approximately the midpoint of the test section. Spot speeds for the individual vehicles were measured at three different points: (1) 1.25 miles upstream from the patrol car, (2) at the patrol car, and (3) 1.25 miles downstream from the patrol car. Results indicated that the average speed of the traffic was lower at the downstream observation point than the average speed of the same vehicles at the upstream point. In addition, there was a decrease in the number of vehicles violating the posted speed limit between the upstream and downstream points. It was also found that the speed variance decreased at the enforcement symbol.

In contrast, the effect upon traffic behavior was different when the patrol car was moving rather than stationary. It was found that for cars in the oncoming stream of traffic (i.e., traveling in a direction opposite from that of the patrol car), there was either no change in mean speeds between the two points upstream and downstream, or an increase in mean speed between the two points. There was a corresponding increase in the number of vehicles violating the speed limit downstream from the patrol car as compared with the cars upstream. Thus, the results of this study indicated that the halo effect associated with a driver passing a stationary patrol car is more desirable than that associated with a driver passing an oncoming, moving patrol car.

As was previously mentioned, one of the questions to be answered by this current study is whether the speed check zone sign has come to be associated with the presence of patrol cars so that a halo effect now exists. The driving public could learn of the relationship between the sign and patrol cars from two sources: (1) information passed to the public through the

news media, and (2) information gained through word of mouth or personal experience.

These factors were important in a study performed by Reinfurt, Levine, and Johnson (1973) which indicated that if drivers learn that their speed will likely be checked, they will alter their driving behavior. This study was designed to determine what variables, such as the presence of radar, visibility of a patrol car, ticketing, and/or media publicity most affected the traffic speed in several cities in North Carolina.

An experimental design was drawn up consisting of five experimental conditions in which these variables were manipulated over a period of eleven days. Among other things, it was possible to determine the effect upon traffic speed of the display of a patrol car on the same road over a period of days. In some cases, newspaper stories were run in local papers in order to notify the public that the police were monitoring traffic speed by means of radar. It was found that the presence of the patrol car resulted in a reduction of mean speed and speed violation rate at the patrol car location over a period of days. In addition, it was found that there was a further reduction in speed and violation rate at the patrol car location when media publicity of the police actions was present. Thus, it is evident that drivers will modify their driving behavior when they know that their speed is likely to be checked.

Generalizing these findings to the present study, it is reasonable to assume that if the motoring public has received enough exposure to the meaning of the speed check zone sign, traffic speed would be modified accordingly. A halo effect similar to the one discussed by Council would then be expected. This would have the effect of lowering the mean speed and legal speed limit violation rate.

PROCEDURE

In order to determine if the speed check zone sign has come to be attended by a halo effect and whether that halo effect extends twenty miles, two test sections of highway which reflect a difference in roadway type were selected in the Wake County, North Carolina area. A 20 mile section of U.S. 70 (a four lane highway) between Garner and Smithfield was chosen for one test site; a 12 mile section of U.S. 64 between Pittsboro and Siler City (a two lane road) served as the other test site. Five speed monitoring stations were established for each test site in order to determine the speed of the traffic along the road (see Figure 2). These stations were approximately equidistant for the two sections of highway (i.e., approximately 3 miles apart on U.S. 64, 5 miles apart on U.S. 70).

HSRC members sitting in either staff cars (unmarked) or their own private (civilian) cars monitored traffic speed with a stationary radar which was located inside the cars and concealed from view. The speed data were collected under three specified conditions for both directions of traffic:

1. The control condition. There were no warning signs or patrol vehicles present. Only HSRC members in civilian cars were present at the data collection sites shown in Figure 2. These data represent the baseline to which the remaining speed data for other conditions were to be compared.
2. The trooper experimental condition. No warning signs were used, but a patrol unit replaced the HSRC vehicle at the midpoint of the test segment. The patrol unit was conspicuously displayed on the roadway shoulder at the middle of the 5 sites (site 3) and had a radar speed monitoring device attached outside the vehicle in order to clearly demonstrate to motorists that their speed was

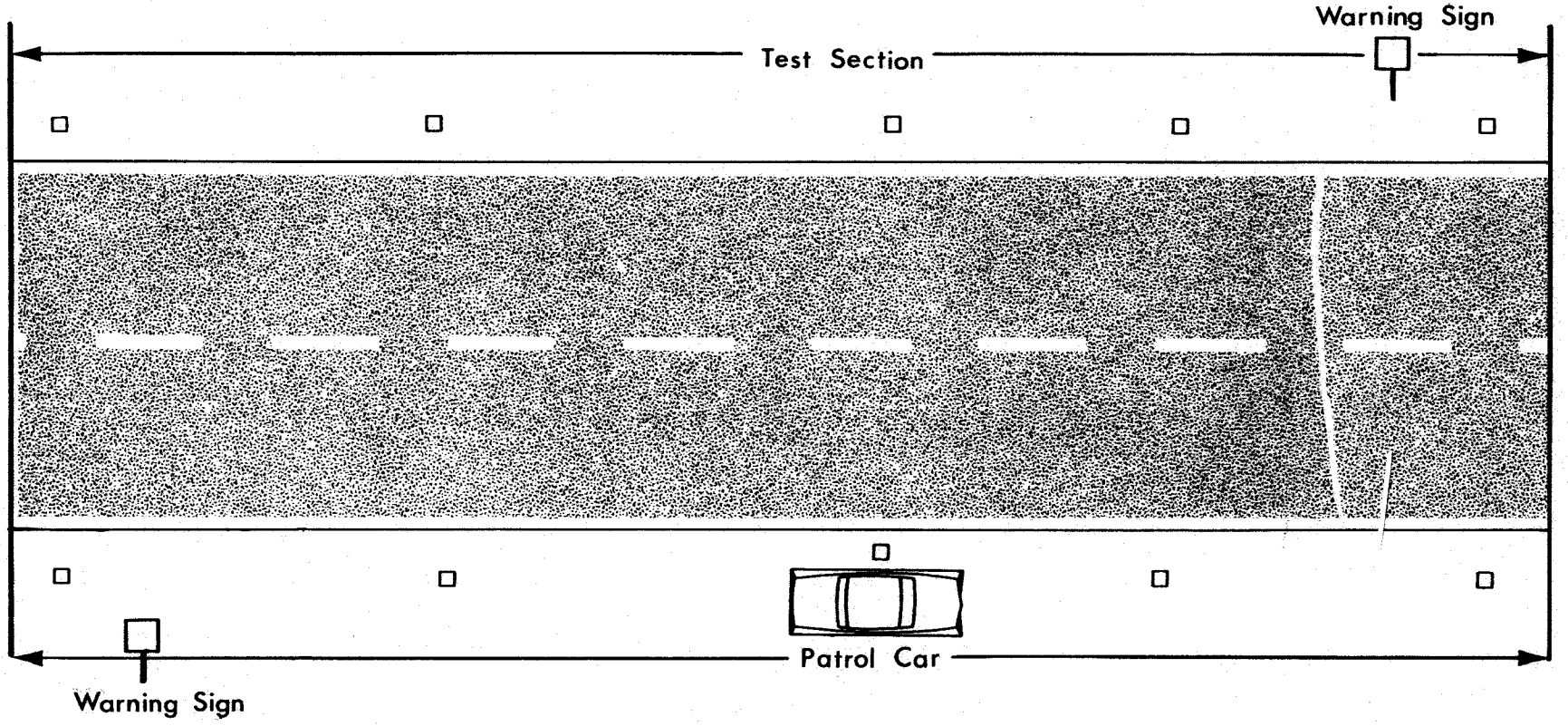


Figure 2. Typical layout of the experiment for the test sections of roadway.

being checked. This condition was provided to determine both the immediate and halo effect of a stationary patrol car monitoring traffic speeds, as compared to the control data.

3. The trooper and sign experimental condition. This condition was similar to the trooper experimental condition, except that a warning sign indicating "Speed Check Zone" was displayed between the first 2 stations at either end of the test section (see Figure 2). Thus, vehicles traveling in both directions would receive advance warning that their speed would be monitored. This condition was provided in order to ascertain whether there was a halo effect associated with the sign and the range of the halo effect.

Past experience has shown that traffic speed varies according to many factors, such as the time of day, the weather, and whether the day is during the week or weekend. Therefore, such influencing factors as these were controlled for in the data collection. Data were gathered only on Tuesdays, Wednesdays, and Thursdays during good weather. One full day was allotted for the collection of data for each condition at each site. Efforts were made to gather about half of the data during the morning and half in the afternoon. In addition, the radar units were calibrated several times a day in order to ensure their accuracy.

Approximately 300 "free-flowing vehicles" were monitored for each direction at each site for each condition ("free flowing" vehicle being defined as a single vehicle or the first vehicle in a queue of vehicles). These vehicles were presumably traveling at their desired speed. Trucks were included in the samples.

After the data for one direction had been collected, the patrol trooper would shift his vehicle to the other (opposite) shoulder before

collecting the data for the opposite direction. In other words, the patrol vehicle was always oriented in the same direction as the traffic flow. The HSRC vehicles did not always shift from one side of the roadway to the other. This was, of course, dependent on the suitability of the site for monitoring both directions.

The data for the control and trooper experimental conditions were gathered in late August, 1974. The trooper and sign experimental condition data were gathered in November, 1974, after giving the public what was presumed to be sufficient time to determine the meaning of the signs.

RESULTS

As noted in the Introduction and Procedure sections, specific questions concerning the existence and range of any halo effect associated with the Speed Check Zone sign were to be investigated. Several methods were used to analyze the data, including an examination of the mean speeds, variances, cumulative speed distributions, and percentage of vehicles exceeding the posted speed limit for each condition. The data that were analyzed are presented for reference in the following manner:

1. The mean speeds, standard deviations, variances, and volumes for each of the speed measuring stations on the two test roadways can be found in Table 1. The data are also categorized by direction of travel and condition.
2. Tables 2-5 are extracted from Table 1 and present the mean speeds by site and direction of travel for the various conditions.
3. Tables 6-9 present the variances by site and direction of travel for all three conditions.
4. The cumulative speed distributions for each site by direction of travel have been graphed and are presented as Figures 3-6.
5. The percentage of vehicles traveling faster than 55 miles per hour, the legal speed limit, can be found in Tables 10-13. These percentages were also plotted and are shown in Figures 7 and 8.

It should be noted that attention must be paid to the direction of travel of the vehicles which generated each block of data. This is because cars traveling in opposite directions on the same test route would encounter the speed measuring stations in opposite order (i.e., Station one on U.S. 64 was encountered first by cars traveling West, last by cars traveling East.)

Table 1. Mean speeds, standard deviations, variances, and volumes for each condition by roadway test section by site.

Location	Condition	Direction of Travel	Site	Mean Speed (mph)	Standard Deviation (mph)	Variance (mph)	N
U.S. 64 East	Control	↑	1	43.003	5.289	27.977	300
			2	54.857	5.754	33.107	300
			3	55.114	5.547	30.766	254
			4	54.453	5.651	31.935	300
			5	54.433	4.670	21.813	300
U.S. 64 West	Control	↓	1	43.333	5.659	32.029	300
			2	52.147	4.632	21.458	300
			3	53.848	4.529	20.516	250
			4	52.153	5.148	26.506	300
			5	54.957	4.754	22.604	300
U.S. 64 East	Trooper	↑	1	48.343	5.652	31.948	338
			2	53.917	4.925	24.251	300
			3	49.000	4.420	19.534	250
			4	53.403	4.801	23.045	300
			5	52.863	4.746	22.527	300
U.S. 64 West	Trooper	↓	1	48.787	6.267	39.280	300
			2	51.390	5.042	25.423	300
			3	49.564	4.079	16.641	250
			4	50.920	4.916	24.168	300
			5	53.193	3.996	15.969	300
U.S. 70 West	Control	↑	1	53.470	6.331	40.084	300
			2	53.027	4.248	18.047	300
			3	54.617	4.071	16.573	300
			4	53.727	3.822	14.608	300
			5	54.610	4.055	16.447	300

Table 1. (Continued)

Location	Condition	Direction of Travel	Site	Mean Speed (mph)	Standard Deviation (mph)	Variance (mph)	N
U.S. 70 East	Control	↓	1	54.080	5.093	25.934	300
			2	51.797	4.350	18.919	300
			3	53.000	3.927	15.425	300
			4	54.430	4.002	16.012	300
			5	53.520	5.400	29.161	300
U.S. 70 West	Trooper	↑	1	53.863	6.167	38.032	300
			2	55.183	5.005	25.047	300
			3	52.970	3.487	12.157	300
			4	54.043	3.289	10.818	300
			5	54.217	4.282	18.338	300
U.S. 70 East	Trooper	↓	1	55.677	4.659	21.705	300
			2	55.337	3.750	14.064	300
			3	53.757	3.947	15.577	300
			4	54.777	5.147	26.469	300
			5	52.295	4.587	21.045	281
U.S. 64 East	Trooper and Sign	↑	1	51.103	4.425	19.578	300
			2	54.040	4.165	17.348	273
			3	50.430	4.672	21.824	214
			4	54.670	4.322	18.677	300
			5	55.899	5.405	29.212	258
U.S. 64 West	Trooper and Sign	↓	1	50.236	5.017	25.174	275
			2	52.523	4.860	23.622	300
			3	51.800	3.984	15.874	300
			4	53.823	4.200	17.639	300
			5	53.900	4.387	19.248	300

Table 1. (Continued)

Location	Condition	Direction of Travel	Site	Mean Speed (mph)	Standard Deviation (mph)	Variance (mph)	N
U.S. 70 West	Trooper and Sign	↑	1	53.373	6.235	38.878	300
			2	54.330	4.535	20.570	300
			3	52.890	4.498	20.232	300
			4	55.747	4.381	19.194	300
			5	56.870	4.557	20.769	300
U.S. 70 East	Trooper and Sign	↓	1	54.757	4.831	23.336	300
			2	53.630	4.616	21.305	300
			3	54.107	3.351	11.227	300
			4	56.763	3.803	14.463	300
			5	55.233	4.592	21.090	300

Mean Speeds

The first method used to determine what effect, if any, the presence of the patrol car and sign had upon speed was the comparison of the mean speeds of the various groups. In order to establish that there was an effect, it was decided to compare the mean speed for the drivers in the control condition to the mean speed of the drivers in each of the experimental conditions for the same speed measurement stations. As indicated, Table 1 shows the mean speeds, the standard deviations, variances, and volumes for the various groups.

It was hypothesized that the mean speeds at the stations before the display of the patrol car or sign[1] (e.g. the first stations encounted) would be the same for all conditions. If the stimuli of the patrol car or sign had any effect, the mean speeds would be significantly different at the station where the stimulus was displayed and also downstream from this station if a halo effect was associated with the stimulus.

Unfortunately, it was found that the mean speeds for the pre-stimulus display stations for the control and experimental conditions were different. There was no difference in the experimental design between these two conditions for the first two sites encountered by traffic since the highway patrol car was located at the middle station in the experimental condition. There were two of these stations for each test road and each direction of travel; thus, there were eight stations in all. It would be expected that the mean speed of the cars would be the same in the control and experimental conditions

[1]"Sign" refers hereafter to condition 3, where the speed check zone signs and a patrol vehicle were used simultaneously. "Patrol car," or "car" refers to condition 2, where the vehicle was situated at the middle data collection site.

Table 2. U.S. 64 - Mean Traffic Speed - Direction of Travel: East (Site 5 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling East ↑	1	43.003	48.343	51.103
	2	54.857	53.917	54.040
	3	55.114	49.000	50.430
	4	54.453	53.403	54.670
	5	54.433	52.863	55.899

Table 3. U.S. 64 - Mean Traffic Speed - Direction of Travel: West (Site 1 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling West ↓	1	43.333	48.787	50.236
	2	52.147	51.390	52.523
	3	53.848	49.564	51.800
	4	52.153	50.920	53.823
	5	54.957	53.193	53.900

Table 4. U.S. 70 - Mean Traffic Speed - Direction of Travel: East (Site 1 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling East ↓	1	54.080	55.677	54.757
	2	51.797	55.337	53.630
	3	53.000	53.757	54.107
	4	54.430	54.777	56.763
	5	53.520	52.295	55.233

Table 5. U.S. 70 - Mean Traffic Speed - Direction of Travel: West (Site 5 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling West ↑	1	53.470	53.863	53.373
	2	53.027	55.183	54.330
	3	54.617	52.970	52.890
	4	53.727	54.043	55.747
	5	54.610	54.217	56.870

for these eight sites. However, it was found that the mean speeds were significantly different at five of the eight sites (z test, $p < .05$).

In the trooper and sign experimental condition, the drivers saw the speed check zone sign between the first and second stations. Thus, the sign should not have affected drivers in this condition at the first station, so that their speed would be expected to be similar to that of the drivers in the control condition at this station. There were four of these pre-stimulus display stations: one for each direction of travel for each of the two sites. Of these four stations, the mean speeds of the control and sign experimental conditions were found to be different three times (z test, $p < .05$). The mean speeds for the above situations can be found in Tables 2-5.

Site 1 on U.S. 64 seems to exhibit a great deal of variation, as reflected by the mean speeds. This is likely due to the location of this station, approximately one-half mile west of the Pittsboro city limits. The posted speed limit at this station was, of course, 55 miles per hour, but the close proximity to the city limits, where a 35 mile per hour limit was in effect, probably prevented many vehicles from reaching a 55 mile per hour speed at this point. Thus, the location for this site was probably unsuitable.

Since it was found that the mean speed of the drivers in the control and the experimental conditions were different before the experimental stimuli were displayed, one must conclude that the samples were drawn from different populations. This fact is very puzzling, in that care was taken to control for the various known factors that could lead to differences, such as weather, time of day, weekday versus weekend, etc.

In an effort to determine why the means of these samples were different, the autocorrelation function was computed for each of the series of 300 speed observations at the site which was first encountered by the motorist

in the control condition. These sites were number 5 for vehicles traveling east on U.S. 64, number 1 for vehicles traveling west on U.S. 64, number 1 for vehicles traveling east on U.S. 70, and number 5 for vehicles traveling west on U.S. 70. The autocorrelation function of these observations measures the correlation between adjacent speed observations, observations 2 lags apart, observations 3 lags apart, etc. If there were significant autocorrelation within the observations (i.e. if the speed observations were dependent), then the variance of the estimate of the mean speed would be larger than the sample variance computed, and an adjustment would have to be made in testing for equality of the means at the initial sites. However, since only speeds of "free-flowing" traffic were recorded, it was not expected that significant autocorrelation would be present at the initial sites.

The computed autocorrelation functions are shown in Appendix A. The dashed lines are the two standard error limits, assuming that there is no autocorrelation between observations. It can be seen from these plots that only at site 1 on U.S. 64 west is there significant autocorrelation in the speed observations. In other words, this is the only figure in which a significant number of the plotted points fall outside of the two standard error limits. This is the site nearest the city limits of Pittsboro, and the autocorrelation can be explained by noting that the vehicles were probably accelerating at this site, and had not reached a stable traveling speed at this point. Since no significant autocorrelation was found in the observations, the tests for equality of the means were judged to be valid as done. (The interested reader should see Box and Jenkins, 1970 for background information pertaining to the autocorrelation technique.)

Since the mean speeds of the pre-stimuli stations were different, it was impractical to test for differences in the groups after the stimuli were

displayed without making rather radical assumptions about the data. However, it was believed that by examining the various data presented in Tables 1-13 and Figures 3-6 as a whole, any trends present could be identified.

Although it is true that there is more variation in these data than is to be desired, the analyses are still sensitive enough to reflect an effect due to the presence of the stationary patrol car similar to that discussed by Council (1970) and Reinfurt, et al (1973). However, upon examination of the data presented in all of the tables and figures mentioned previously, it is evident that the speed check zone sign had a minimal, if any, effect upon the driving behavior of the public.

An examination of Tables 2-5 indicates that the mean speed of the drivers in the two experimental conditions was lowest in practically every case at the third station (where the patrol car was located). This was not the case with the control group data. This situation is very apparent in Table 2 and 3, which apply to the two-lane roadway. Therefore, the presence of the patrol car tended to reduce the mean speed of the traffic, an expected finding.

Tables 2-5 also show that the effect of the trooper (in terms of mean speeds) was dissipated very quickly downstream, especially in condition 3, where the speed check zone sign was also used. Thus, the halo effect was apparently not extended by the use of the sign.

Variances

Tables 6-9 show the variance of the traffic speed by site and condition. Again, the control condition is different from the experimental conditions before the display of the stimuli, so that further statistical testing was

Table 6. U.S. 64 - Traffic Speed Variance - Direction of Travel: East (Site 5 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling East ↑	1	27.977	31.948	19.578
	2	33.107	24.251	17.348
	3	30.766	19.534	21.824
	4	31.935	23.045	18.677
	5	21.813	22.527	29.212

Table 7. U.S. 64 - Traffic Speed Variance - Direction of Travel: West (Site 1 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling West ↓	1	32.029	39.280	25.174
	2	21.458	25.423	23.622
	3	20.516	16.641	15.874
	4	26.506	24.168	17.639
	5	22.604	15.969	19.248

Table 8. U.S. 70 - Traffic Speed Variance - Direction of Travel: East (Site 1 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling East ↓	1	25.934	21.705	23.336
	2	18.919	14.064	21.305
	3	15.425	15.577	11.227
	4	16.012	26.469	14.463
	5	29.161	21.045	21.090

Table 9. U.S. 70 - Traffic Speed Variance - Direction of Travel: West (Site 5 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling East ↑	1	40.084	38.032	38.878
	2	18.047	25.047	20.570
	3	16.573	12.157	20.232
	4	14.608	10.818	19.194
	5	16.447	18.338	20.769

deemed to be impractical. An examination of Tables 6-9 fails to reveal any strong trends as to the relationship between the variances and the different conditions. For example, Table 6 shows the variance to successively increase at sites 2 and 1 for condition 2. For condition 3, the variance decreases at site 2 and then increases at site 1. The control condition for Table 6 looks unlike either condition 2 or 3. Similar fluctuations appear in Tables 7-9. One can only speculate as to why such differences exist.

Cumulative Speed Distributions

Since the mean speed and variance data seemed to fluctuate, it was decided to examine the cumulative speed distributions for each site and condition. These are shown as Figures 3-6. The figures are grouped into sets of five for each site. For example, Figures 3A-3E pertain to the 5 stations measuring east bound traffic on U.S. 64. The effect of the patrol vehicle can clearly be seen in Figure 3C. In the control condition, approximately 50 percent of the vehicles were exceeding the posted speed limit. However, when the trooper was present, conditions 2 and 3, approximately 90 percent of the vehicles were traveling less than the posted limit. This effect is not lasting, for once the vehicles passed the patrolmen, many returned to speeds greater than the 55 mile per hour limit. The same trend holds for U.S. 64 West, Figures 4A-4E.

The figures that pertain to U.S. 70, the four-lane roadway, look similar to the above, except that the effect of the patrol vehicle is not as great at Station 3. In Figure 5C, the percentage of vehicles exceeding the speed limit in condition 2 and 3 is approximately 25 percent, as opposed to approximately 10 percent on the two-lane roadway. The effect

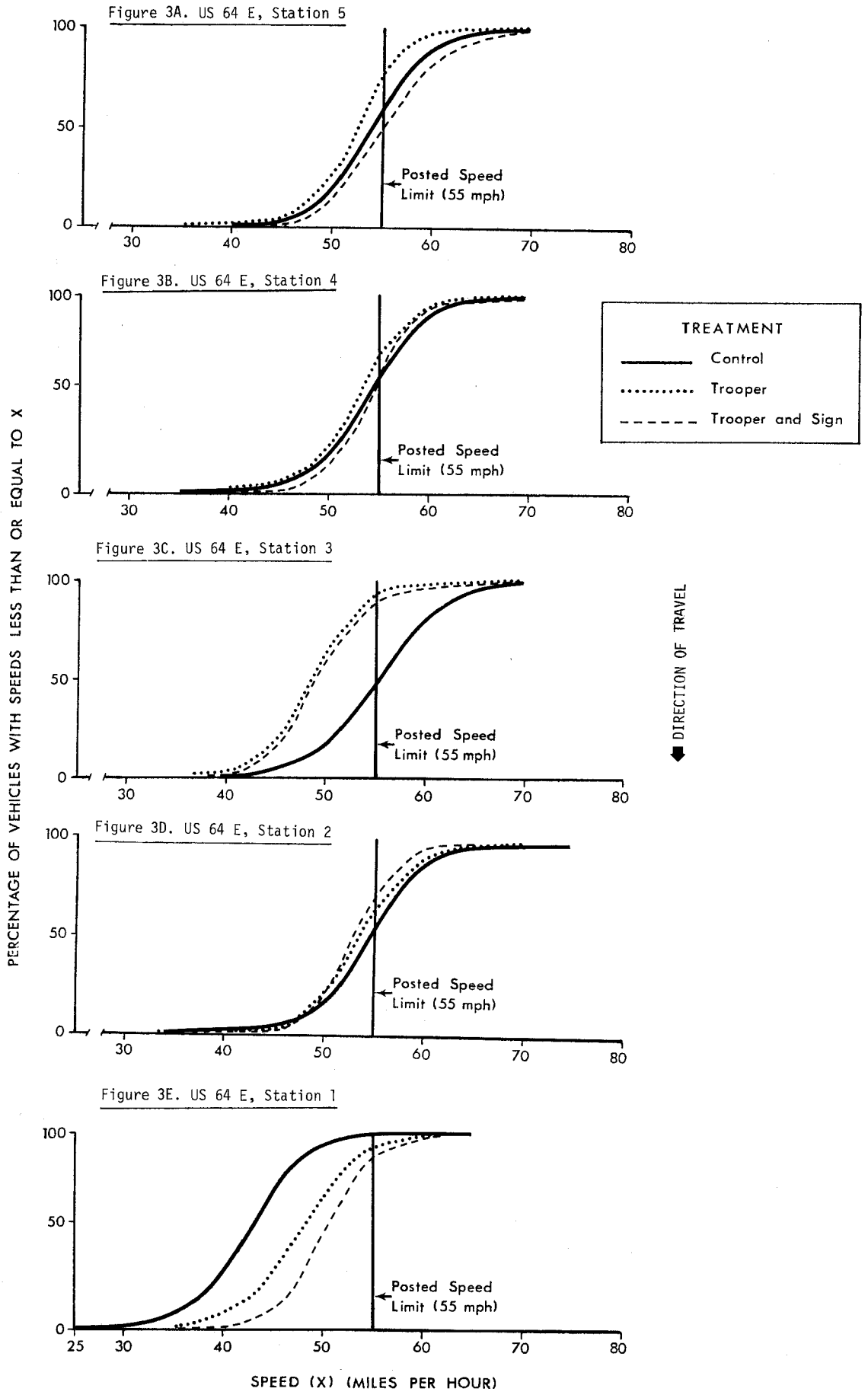


Figure 3. Cumulative speed distributions for the five data collection stations on U.S. 64 East.

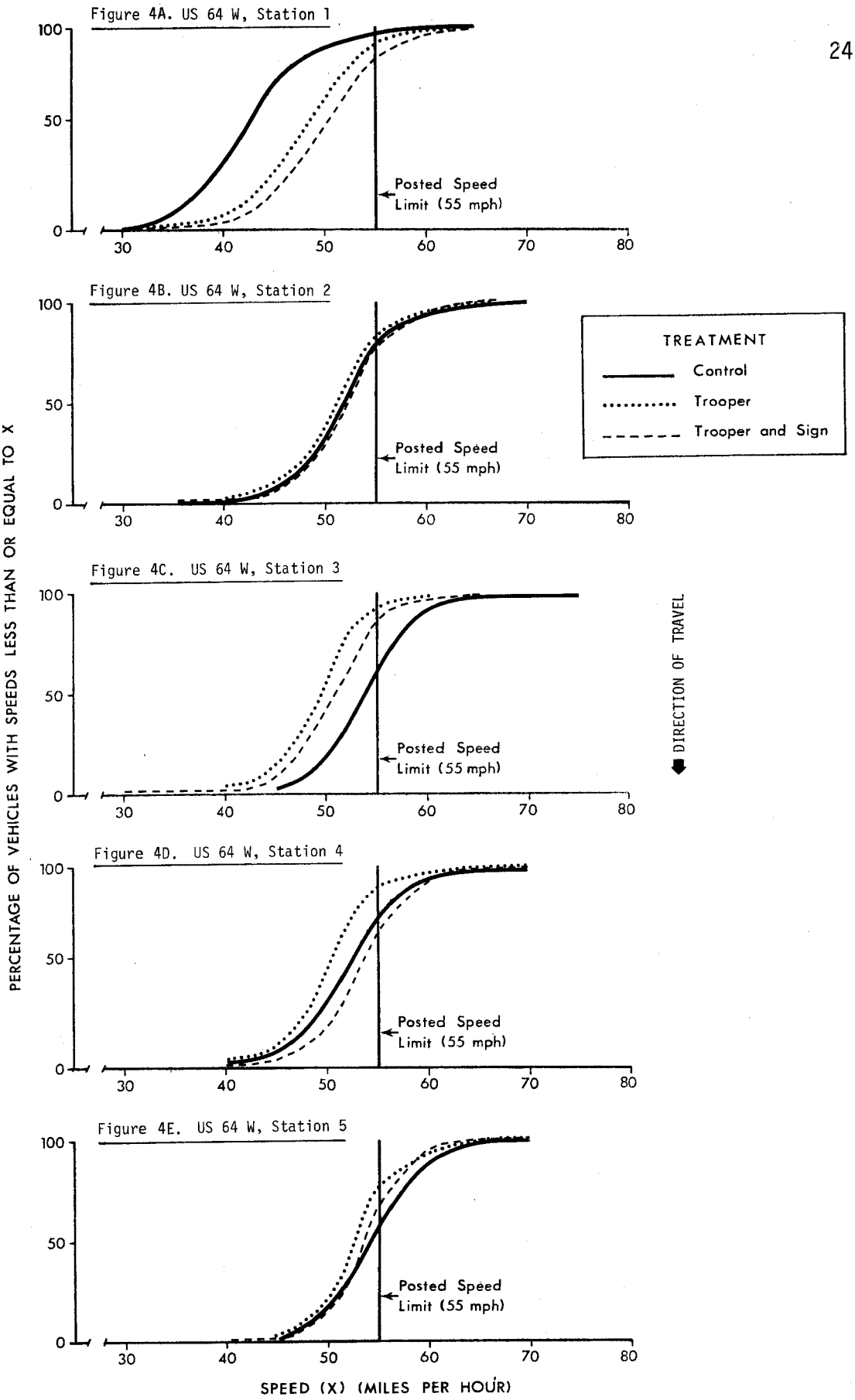


Figure 4. Cumulative speed distributions for the five data collection stations on U.S. 64 West.

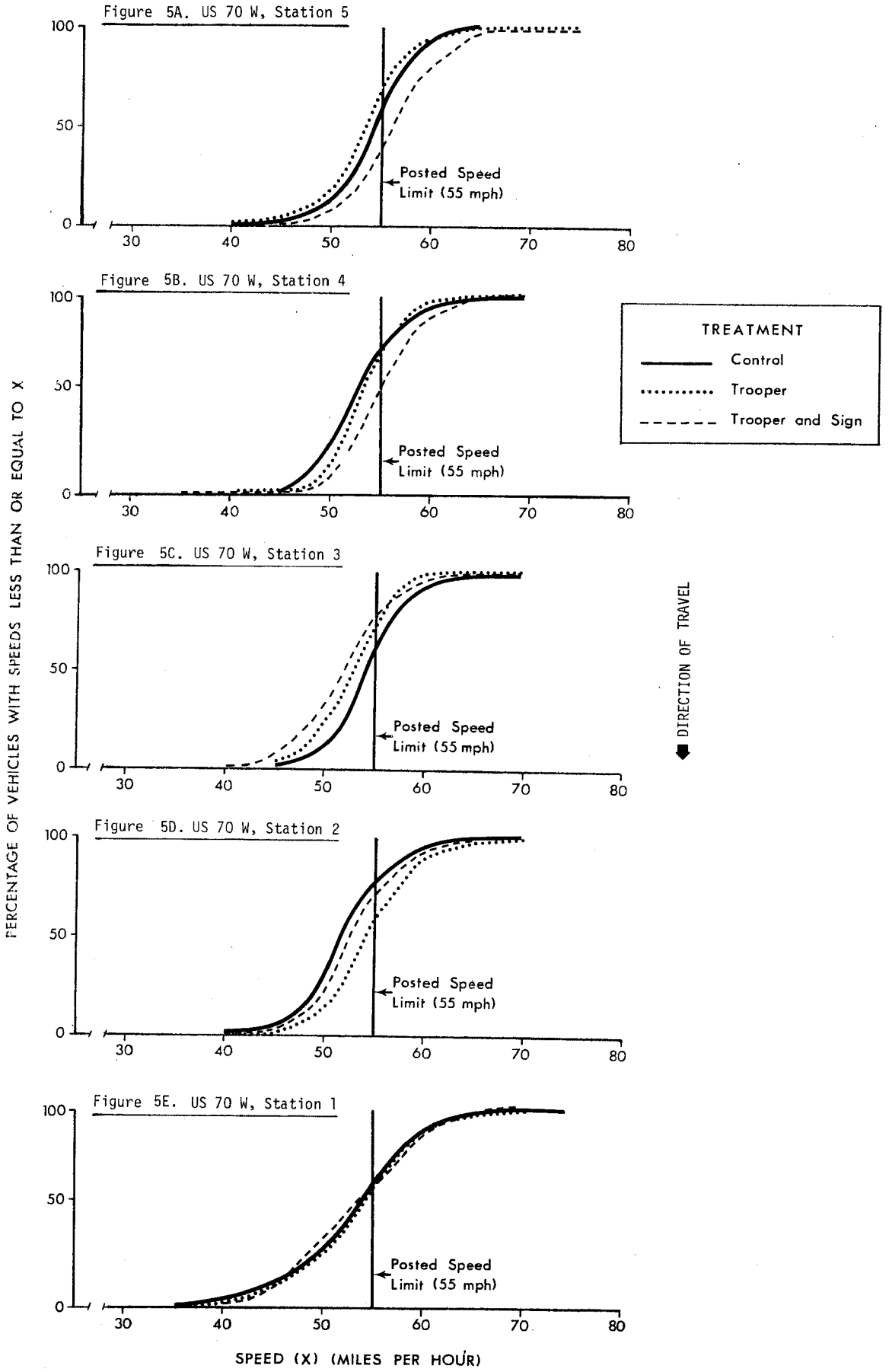


Figure 5. Cumulative speed distributions for the five data collection stations on U.S. 70 West.

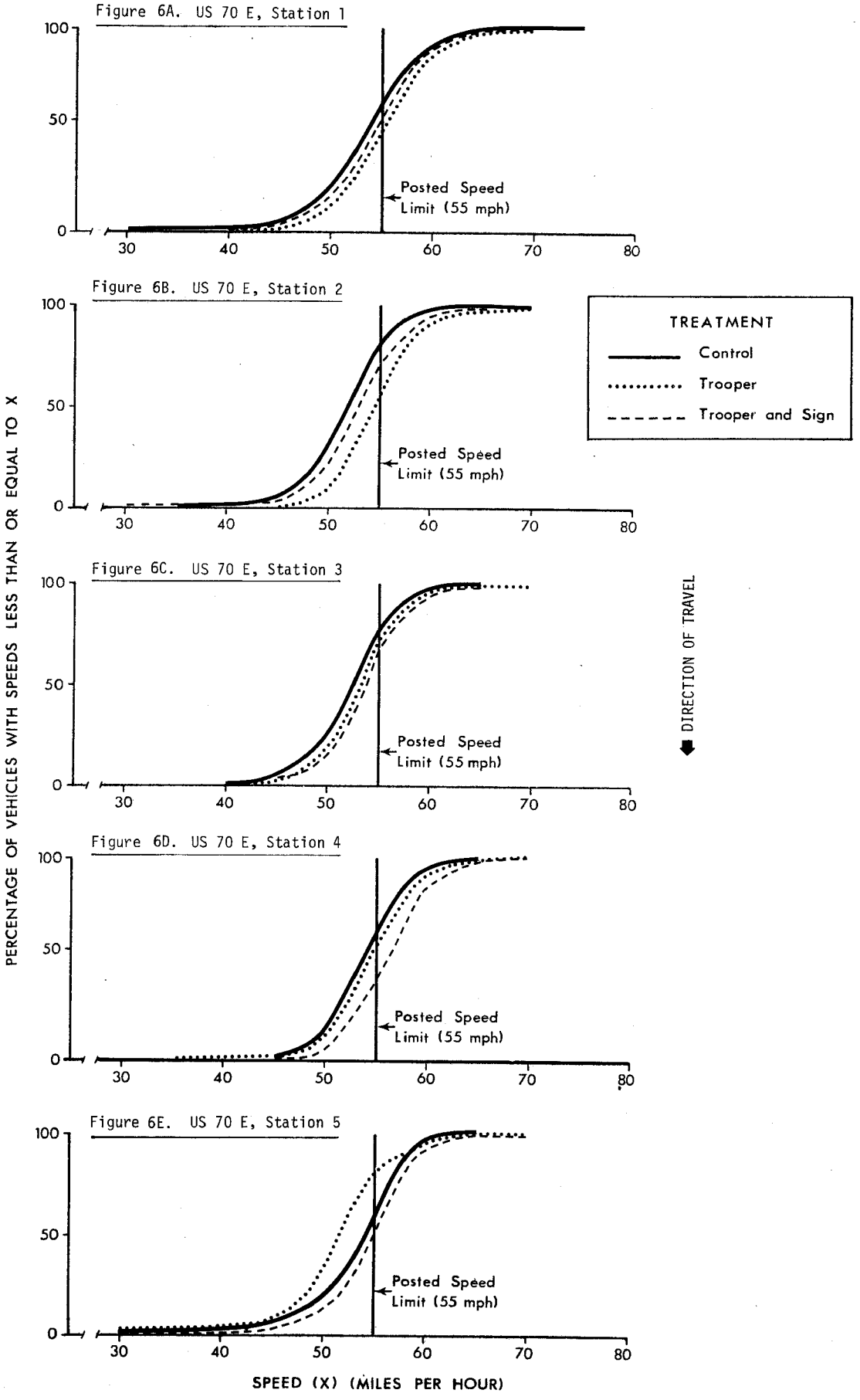


Figure 6. Cumulative speed distributions for the five data collection stations on U.S. 70 East.

is again lost at the adjacent downstream station, indicating that the use of the sign is simply not extending the halo effect for any appreciable distance.

One interesting fact does emerge from the examination of the cumulative speed distributions, namely, that the slope of the distributions tends to be steeper for those stations where the patrol vehicle was located. This illustrates the decrease in the speed variance. Thus, the decrease in the mean speeds at these stations in due primarily to the faster vehicles slowing down, rather than the entire population of vehicles slowing down. Interestingly, this effect was greatest on U.S. 64, the two-lane roadway.

Percentage of Vehicles Exceeding the 55 mile per hour limit

Tables 10-13 and Figures 7-8 are concerned specifically with the percentage of vehicles traveling greater than the 55 mile per hour posted limit. The same trends emerge as before, where the percentage of vehicles speeding at the middle stations (Station 3) was much lower for the two experimental groups, except for the cars traveling east on U.S. 70. Again, it is interesting to note that this effect seems greatest on the two-lane road, U.S. 64.

Summary of Analyses

In conclusion, the above discussion suggests that the trooper and sign experimental conditions had an effect on both the mean speed of traffic and the percentage of vehicles exceeding the posted speed limit at the site where the patrol vehicle was displayed. However, since very little effect can be shown downstream from the patrol car, it would appear that the sign did not accomplish the desired purpose of extending the halo effect. It

should be remembered that the signs were located approximately half way between the first and second stations encountered. Thus, the distance between the sign and the nearest station was from 1.5 to 2.5 miles. Therefore, either there is no significant halo effect associated with the speed check zone, or the effect disappears within 1.5 to 2.5 miles downstream.

PERCENTAGE OF VEHICLES TRAVELING GREATER THAN 55 MILES PER HOUR BY ROADWAY BY SITE BY CONDITION

Table 10. Highway: 64
Direction of Travel: East
(Site 5 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
	1	1.0	6.1	12.0
Vehicles Traveling East ↑	2	44.6	37.1	31.8
	3	48.8	5.2	8.8
	4	42.6	32.0	42.0
	5	41.7	24.0	53.5

Table 11. Highway: 64
Direction of Travel: West
(Site 1 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
	1	2.3	6.6	12.6
Vehicles Traveling West ↓	2	20.7	18.0	22.0
	3	36.4	6.4	9.8
	4	24.7	10.4	33.0
	5	43.0	22.3	33.4

PERCENTAGE OF VEHICLES TRAVELING GREATER THAN 55 MILES PER HOUR BY ROADWAY BY SITE BY CONDITION

Table 12: Highway: 70
Direction of Travel: East
(Site 1 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling East ↓	1	38.7	50.4	44.1
	2	17.4	46.7	28.3
	3	23.3	29.4	32.4
	4	29.7	45.1	62.4
	5	36.7	19.1	51.3

Table.13. Highway: 70
Direction-of Travel: West
(Site 5 encountered first)

		Condition		
		1	2	3
	Site	Control	Trooper	Trooper & Sign
Vehicles Traveling West ↑	1	38.3	40.3	40.7
	2	25.0	44.1	32.4
	3	39.7	26.6	24.0
	4	39.4	32.3	52.7
	5	39.4	31.3	62.0

Figure 7 Percentage of vehicles traveling faster than 55 MPH on U.S. 64.

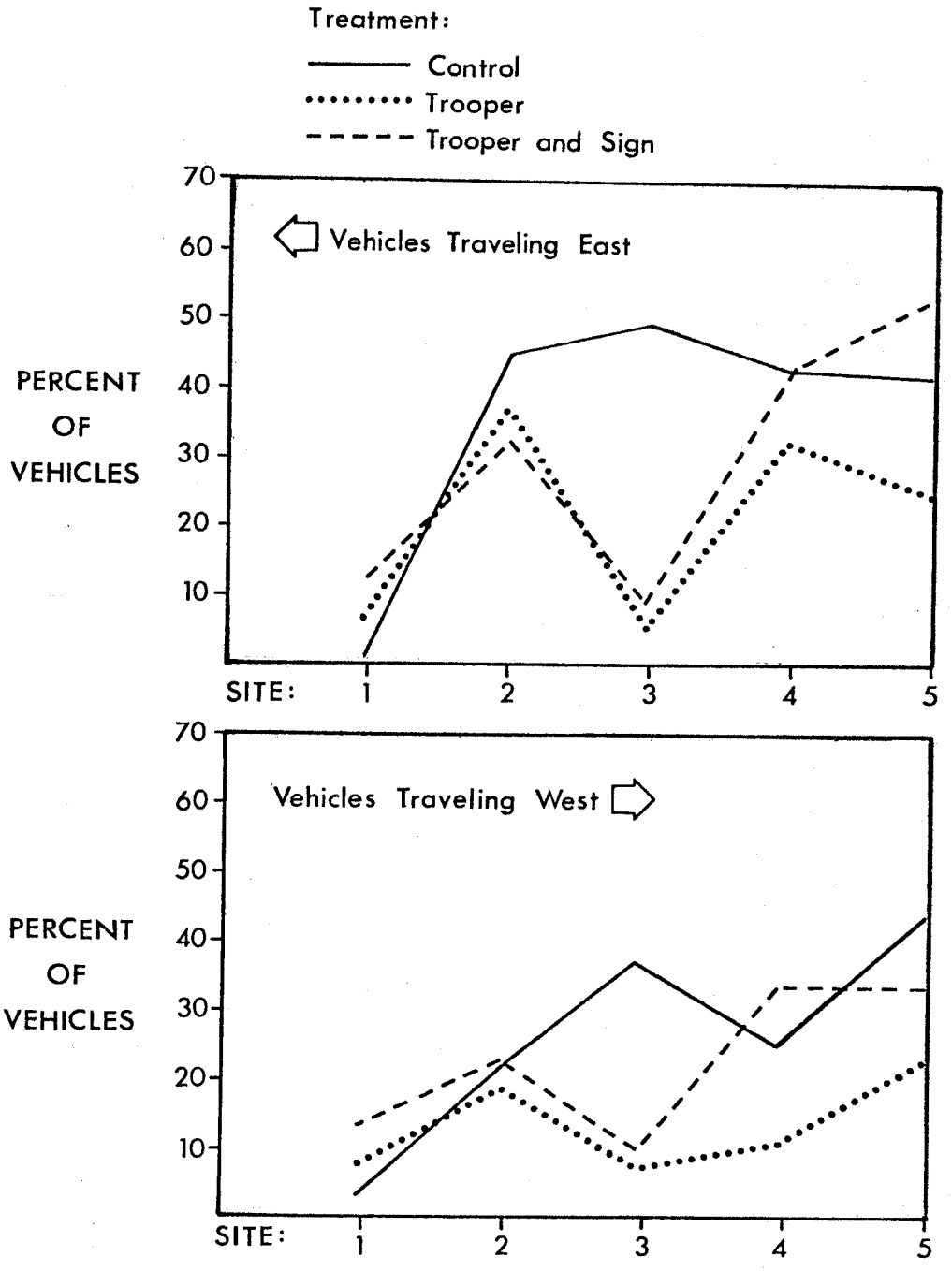
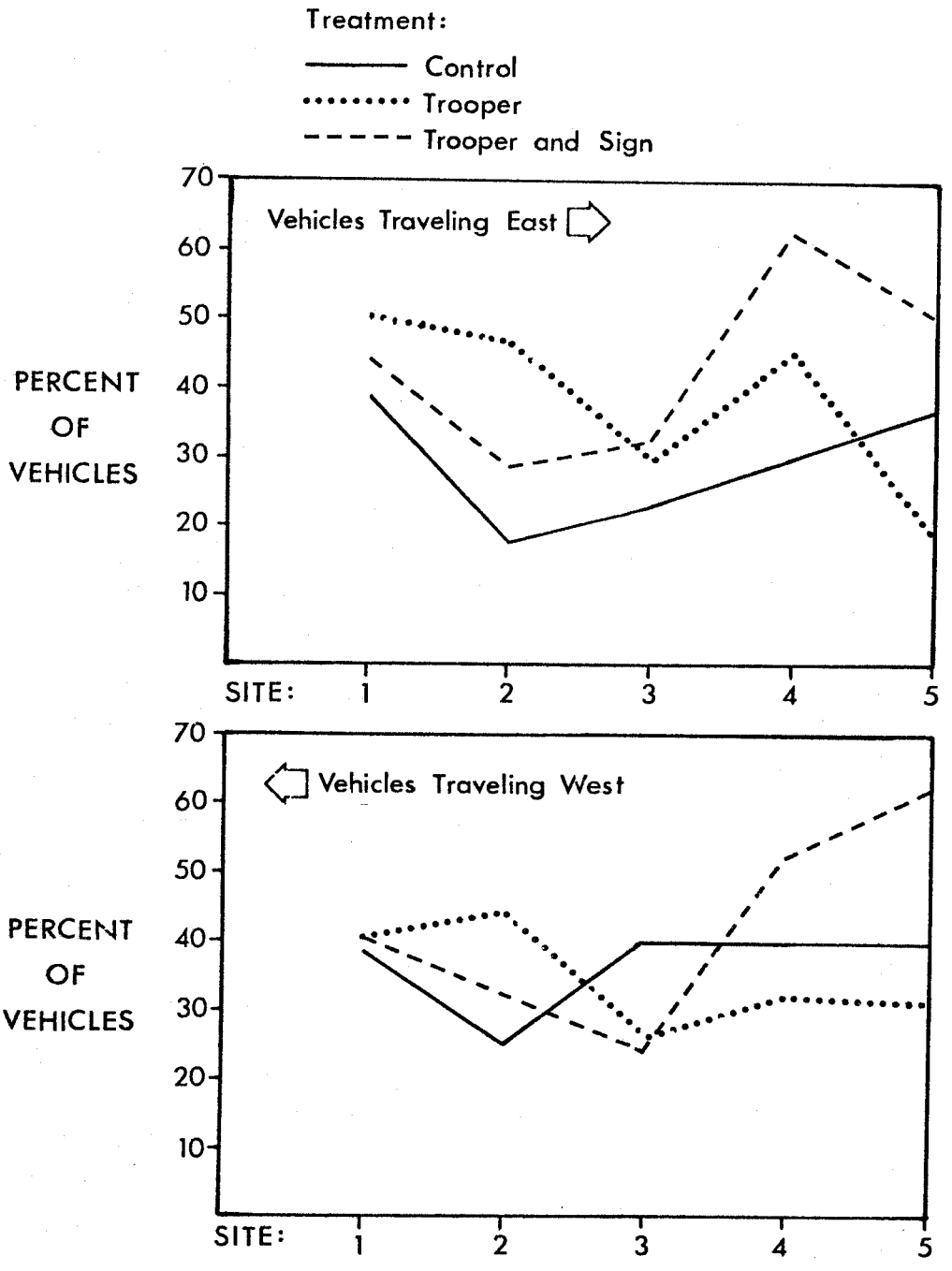


Figure 8. Percentage of vehicles traveling faster than 55 MPH on U.S. 70.



DISCUSSION

The purpose of this study was to determine if the speed check zone sign has come to be attended by a halo effect and whether the halo effect extends over a considerable distance downstream from the sign. Upon examination of the data, no such impact upon driving behavior, in terms of mean speeds, variances, and percentage of vehicles exceeding the posted limit was found to have been attributable to the display of this sign. There are several possible explanations for this:

1. Poor experimental design or inaccurate data. It is not likely that this is the reason no effect was found. The experimental design controlled for factors such as day of week, time of day, weather conditions, etc. These factors have been shown to be associated with spot speed differences from prior research.

Only the speeds of free-flowing vehicles were collected in the samples. The data collectors also used unmarked cars and attempted to be as unobtrusive as possible. For example, rest areas with picnic tables were used as two of the sites on U.S. 64. Even though such care was taken with the placement of the vehicles, commuting drivers may have noticed the data collectors and altered their driving behavior.

The last samples of data, where the sign condition was present, were taken in November, whereas data for the first two conditions were collected in August. The time interval was necessary to give the public a chance to become somewhat familiar with the sign. Seasonal differences which are associated with speed data could have affected the third condition data to some degree. However, differences were detected in the first two conditions also, and these samples were collected within a period of one week.

2. The public did not know what the sign meant. This is probably one reason no effect was detected. It was essential for the success of this program that the public be educated as to the meaning of the sign. This had to be done through the mass media (newspapers, radio, etc.) and also through word of mouth and personal experience which would result from people seeing the signs with highway patrolmen in action nearby. Unfortunately, the highway patrol may not have utilized the signs enough to fulfill this purpose, and the media campaign may not have been widespread enough to have had any significant impact.

The first statewide publicity concerning the speed check zone signs was unfortunately coupled with a release that dealt mainly with a highway patrol experiment to reduce the number of violators exceeding the 55 mile per hour limit. The same article also mentioned the use of new equipment, the moving radar, by the patrol. It is felt that these items may have overshadowed the publicity about the signs.

HSRC sent out follow-up releases about the signs at a later date to not only the major daily newspapers in the state but also the local newspapers in the impact areas of the data collection, but it is difficult to theorize what effect these subsequent articles may have had. The publicity attempts in the Reinfurt (1973) study were at the city level and the sites that were studied were city streets. Since these sites were state highways, a statewide media campaign would have been necessary to reach the majority of the drivers in this study.

Even if such a campaign were successful, past studies have shown that only a certain percentage of people read newspapers. Thus, there is inherent bias in the type of person reached by such communication. Such reasoning would indicate that the sign should be made to be as self-explanatory as possible. (See specific recommendations below.)

3. Frequency and methodology in the use of the signs by the patrol.

It is the strong feeling of HSRC that the signs were used so little that no educational effect could have resulted. Based on contacts with various patrol troopers, it appears that the signs were largely unpopular, perhaps with good reason. Because of visibility requirements, the signs were necessarily bulky. The method of mounting to existing signposts was also rather unwieldy. Since the signs were only to be used when one or more patrol vehicles was in the vicinity, this meant that the signs had to be mounted and then removed every time they were used. These factors tended to limit the usage frequency of the signs.

Coupled with this problem was the method employed in the use of the sign. The original plan was to involve a variety of enforcement conditions, including periodic use of multiple patrol vehicles within the boundaries of the sign with some patrol vehicles moving and some stationary. Various equipment was also to be used, such as stationary radar, VASCAR, and moving radar. It appears that the method used the majority of the time was similar to that employed in the HSRC experiments, whereby only one vehicle was actually enforcing. This certainly would have lessened the educational impact of the signs.

4. The sign was too inconspicuous. The signs which were manufactured for this program were black and white (black letters on a white background) and were 30 inches by 30 inches in dimension. The signs were also attached to existing sign posts whenever possible. If there were other black and white signs on these posts, then the speed check zone sign might blend in so well with the others that it would be difficult for a passing motorist to perceive. There is strong likelihood that if the signs were brightly painted and more conspicuously displayed, they would be more noticeable.

It is unlikely that the assumption that the public would alter their driving behavior because of the presence of a sign or patrol vehicle could have been completely erroneous. It is clear that the public will alter their unlawful driving behavior if they think it is likely that they will be penalized for not doing so. The Council (1970) and Reinfurt (1973) studies, among others in the literature, point this out. The data in this study indicate that the presence of the stationary patrol car certainly had an effect on mean speeds and the percentage of vehicles traveling faster than the legal speed limit. The data was accurate enough to detect the difference. Although there was more variance in the data than was desired, any gross effects upon traffic speed due to the sign would have been detected if present.

Even though the speed check zone sign did not accomplish its intended purpose, it is the feeling of HSRC that the idea was innovative and had a good chance for success. It would appear that the frequency and manner in which the signs were used were the greatest detriments to success. HSRC feels that the signs can become effective in the future if used in more positively reinforcing ways. To be more specific, HSRC would like to make the following recommendations:

1. All types of speed-monitoring equipment should be used.
2. There should be more instances where multiple vehicles are used.
3. The locations of the enforcement vehicles should be varied, so that motorists will not come to associate a definite pattern of speed monitoring when the signs are used.
4. Ideally, the signs should be made to be self explanatory. However, this would involve a change in the message content, which would likely prove to be prohibitive from a cost standpoint.

Thus, the use of the signs should be selectively and periodically publicized.

5. If possible, the signs should be made to be more highly visible. One alternative would be to repaint with brighter colors. However, such a change would have to conform to the standards contained in the Manual on Uniform Traffic Control Devices. A second alternative would be to permanently mount some of the signs in strategic locations across the state. The signs could then be accompanied with flashing lights when speeds were being monitored. This concept would not only make the signs more visible but also alert the public that they were in use.

These recommendations are designed to make a driver who encounters such a sign believe that his speed will soon be monitored. In addition, the driver should also be uncertain as to when or how many times his speed will be monitored. It is believed that because of this uncertainty, and the desire to avoid a speeding citation, the effect of the sign upon driving behavior can be maximized.

If indeed these changes are accomplished, the signs could become a very effective deterrent to those who would violate speed laws. If such an educational effect is achieved, it might be possible to use the signs in the future without always having enforcement vehicles in the vicinity, which would constitute a very desirable effect.

HSRC also feels that it is very important to continue this type of experimental program coupled with evaluation. The North Carolina State Highway Patrol is commended for their efforts in this area. Only through such programs can the maximum payoff for each enforcement dollar spend be realized.

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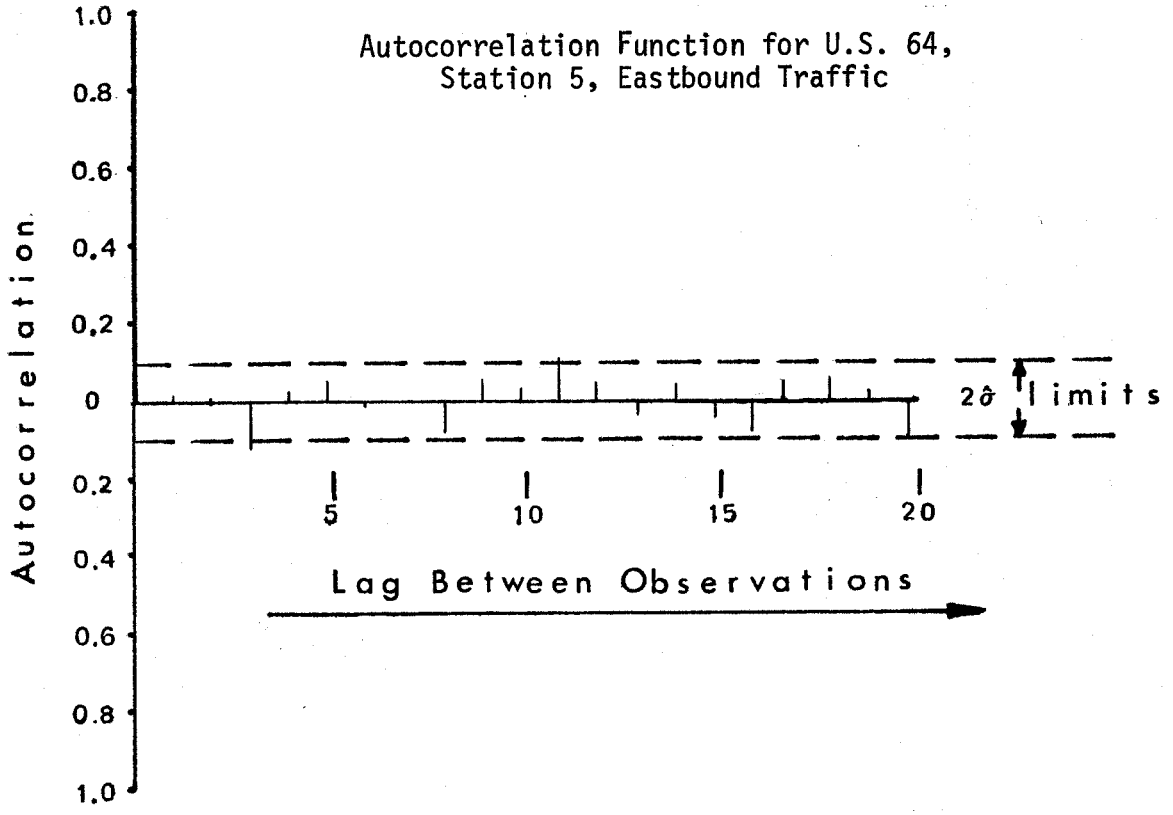
Council, Forrest M., A study of the immediate effects of enforcement on vehicular speeds. University of North Carolina Highway Safety Research Center, 1970.

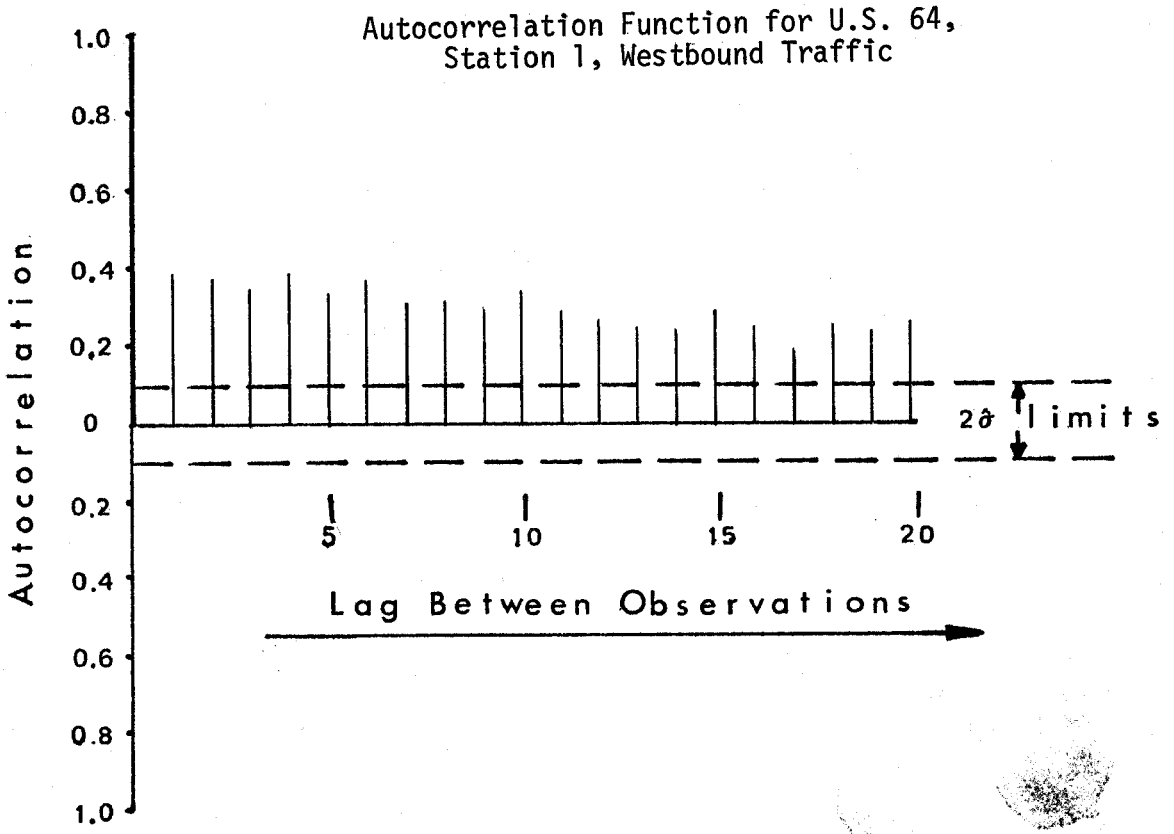
Reinfurt, Donald W., Levine, Donald N., and Johnson, William D. Radar as a speed deterrent: An evaluation. University of North Carolina Highway Safety Research Center, 1973.

U.S. Department of Transportation, Federal Highway Administration. Manual on uniform traffic control devices for streets and highways. Washington, D.C.: U.S. Government Printing Office, 1972.

APPENDIX A

Estimated Autocorrelation Functions for the First Sites Encountered During the Control Condition


Autocorrelation Function for U.S. 64,
Station 5, Eastbound Traffic
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1.0
2σ̂ limits
5
10
15
20
Lag Between Observations


Autocorrelation Function for U.S. 64,
Station 1, Westbound Traffic
Autocorrelation
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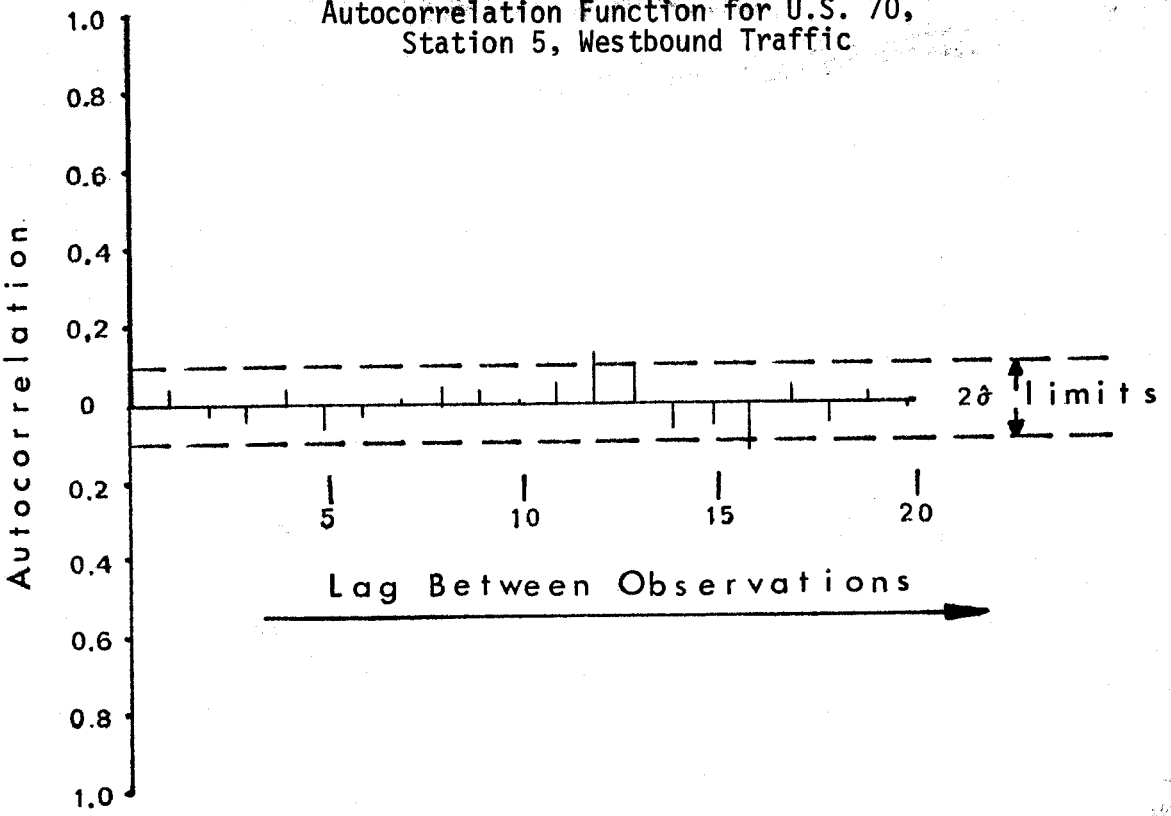
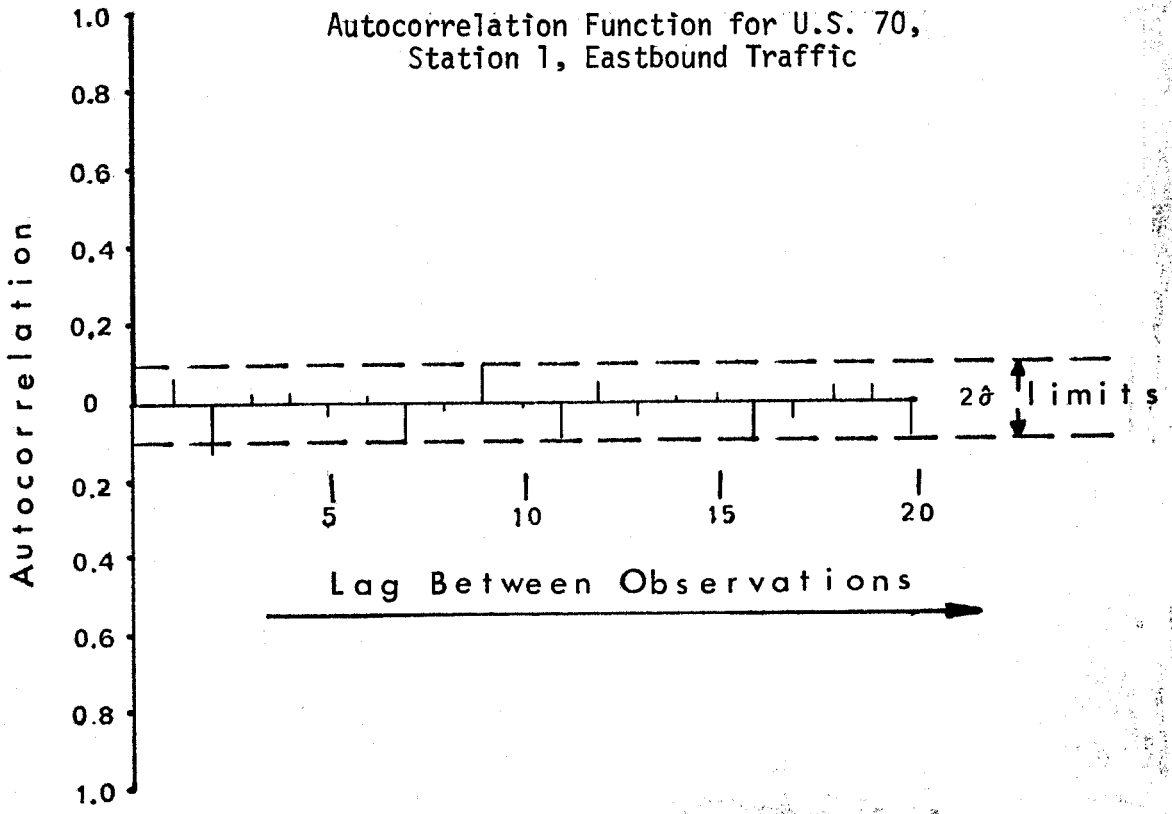
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1.0
2σ̂ limits
5
10
15
20
Lag Between Observations


Autocorrelation Function for U.S. 70,
Station 5, Westbound Traffic
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1.0
2∂ limits
5
10
15
20
Lag Between Observations


Autocorrelation Function for U.S. 70,
Station 1, Eastbound Traffic
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1.0
2∂ limits
5
10
15
20
Lag Between Observations