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Comparison of Laboratory and Field Studies in the Estimation of Driving Speed

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Comparison of Laboratory and Field Studies in the Estimation of Driving Speed[1]

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Introduction

Judgment of speed has long been a matter of interest to students of highway safety. Forbes (1) early devised an apparatus which was used in the laboratory for measuring judgment of speed in the longitudinal direction. His apparatus consisted of a long roadway on which metal tape carried small cars. A control car was allowed to travel in traffic on the right side of the road. At such times as there was danger of a collision the operator was required to turn sharply in order to avoid colliding with another vehicle. The number of times that he failed to dodge in time to avoid a collision was recorded electrically. Essentially it was comparable to having subjects riding in one car judge at what point they would meet an oncoming vehicle.

Reliability of the measurements was established and an attempt was made to ascertain the validity of the apparatus by means of a road test. In the latter several persons were asked to judge the speed of passing cars. The estimates were correlated with the apparatus and some reasonably good differentiations were obtained.

Forbes also experimented with a form of Munsterberg's (3) apparatus in which the estimation of speed was judged along a line at right angles to that of the line of sight. A magnetic device was used so that the errors could be measured by release of a small piece of metal at the point where the subject judged the vehicle crossing the line of travel would be at a given time.

The Chicago Motor Club later devised an apparatus which was very well constructed mechanically. It incorporated the same principles as used by Munsterberg and by Forbes into a so-called speed judgment apparatus. It has three gears which are set at simulated speeds of 37, 60, and 81 miles per hour. The gears can be changed manually by a simple gear-shifting device. A miniature car is made to traverse a window-like opening built into the front of the apparatus. Movement is in a horizontal plane and from left to right with respect to the subject's line of vision. After the car has passed out of sight and has traveled a predetermined distance behind a screen, the electrical circuit to an illuminated light panel is broken. The

[1] This study was made possible through a grant from the American Automobile Association for driving research.

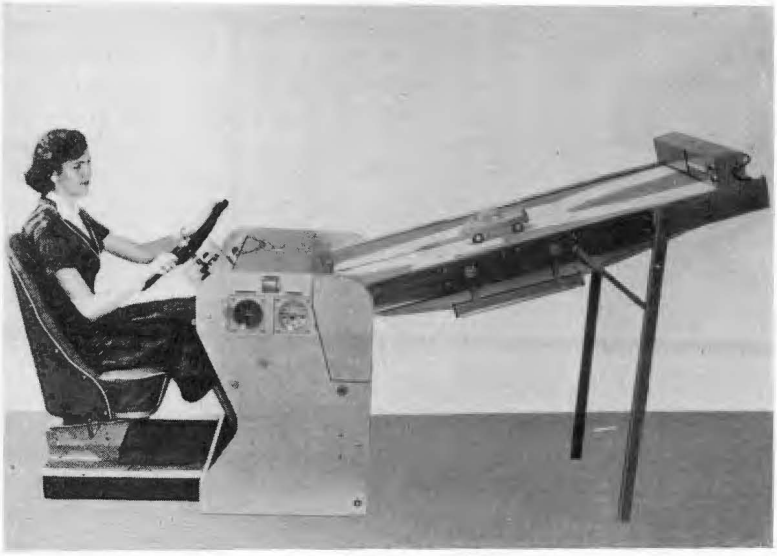
subject responds by stating the number of the point at which he judged the car to be when the light went out.

Oliver (2), using this device in studying the relationship between vision, distance judgment and speed estimation obtained a reliability coefficient of .84 for the speed judgment test by using 30 trials.

A road test to determine ability to estimate speed of cars in an actual driving situation was devised by Forbes (1). Subjects riding in one car were asked to judge at what point they would meet an oncoming vehicle. The car in which the subjects rode ran at the same speed for all trials, while the speed of the approaching car varied from trial to trial.

The problem in the present study is fundamentally that of testing the null hypothesis that there is no difference in the estimation of speed at various rates of travel. A corollary hypothesis was also tested. It may be stated as follows: an indication of skill in speed estimation on the road can be obtained by a laboratory device, namely the Auto Trainer.

The Auto Trainer, shown in Figure 1, is constructed so that the subject uses full-size automobile controls to drive a miniature car around a traveling roadway. The accelerator pedal is attached to a rheostat in such a manner that the speed of the traveling roadway increases as the pedal is depressed. A speedometer indicates a scale speed.



Method of Procedure

A group of 19 male drivers, ranging in age from 25 to 60 years, were used as subjects. Each subject individually made a series of speed estimations under two different conditions. They are here identified as Series I and II.

In Series I the driver estimated the speed at which he was driving the Auto Trainer.

The speedometer was shielded so that it could not be read from the driver's seat. A series of 14 trials was made. Speed requested for a particular trial was determined by random selection. The investigator would call for a particular speed, for example 20 miles per hour. When the subject thought he was driving at a speed equivalent to 20 miles per hour on the road he responded by saying "now". Two estimates were made by each subject for every speed set up for experimental investigation.

Tables were made showing the actual and estimated speeds as recorded for each of the two series of judgments. The average estimate was calculated for each speed selected and from this the average error was determined.

The results for Series I are shown in Table 1.

Series II was similar to Series I except that the speed estimation was made while the subject was behind the wheel of an automobile in an actual traffic situation. The experimenter took each driver out on the road and at 14 predetermined points suggested that the subject get the automobile up to a designated speed at the earliest possible moment. When the driver thought he had attained this speed he said "now". The actual tachograph reading at the moment the subject said "now" and the estimated speeds were recorded. The tachograph, shown in Figure 2, was shielded so that the speedometer could not be seen by the driver. The order of speed selected was picked at random and two estimates were made for each. Comparisons of the estimated and actual speeds were made.

The tabulations of estimates, average estimates, and average errors for Series II are presented in Table 2.

As a means of comparing the magnitude and direction of the errors on the two types of speed estimation studied, graphs were constructed as shown in Figure 3.

An inspection of the graphs will reveal that the drivers used in this study tended to underestimate speeds below 30 miles per hour, that is, actual speed was greater than the subject's estimate of it. The best estimates were made in the 30-50 mile-per-hour speed range. Beyond 50 miles per hour there was a tendency to overestimate, that is the actual speed was less than the estimated speed.

Table 1

Estimated and Actual Speeds in Miles Per Hour[a]
Series I—Auto Trainer

Sub-ject	40	50	20	50	10	70	10	30	40	60	70	60	30	20
1	32	38	30	40	30	42	30	35	38	41	43	40	35	32
2	38	42	30	40	25	45	20	34	37	38	45	40	35	38
3	30	35	15	37	10	40	20	32	38	41	45	40	28	24
4	26	30	18	30	12	40	15	20	28	33	40	38	28	20
5	30	40	25	40	30	42	30	38	38	42	45	42	38	35
6	31	35	20	35	21	40	18	26	32	38	41	39	34	26
7	31	37	22	35	12	42	15	32	35	38	41	38	31	25
8	30	37	32	38	15	40	21	31	38	40	45	40	30	26
9	40	42	30	42	20	45	22	35	38	45	47	44	35	30
10	35	41	27	44	18	47	18	38	40	45	48	44	36	25
11	25	30	20	30	17	38	15	21	25	32	37	32	25	22
12	40	45	32	45	25	47	22	35	40	45	47	45	35	35
13	35	40	30	40	20	45	20	31	38	42	45	40	31	25
14	38	40	35	40	25	44	25	35	40	42	45	44	35	32
15	40	41	35	41	25	45	27	38	42	43	46	40	35	34
16	30	35	21	35	11	40	10	22	28	38	40	38	22	18
17	28	38	25	38	20	40	15	25	32	38	40	40	28	25
18	30	38	23	35	15	38	25	35	38	40	42	38	34	30
19	26	30	15	30	10	38	12	26	28	32	38	30	22	20
Mean	32.4	37.6	25.5	37.6	19.0	42.0	20.0	31.0	35.4	39.6	43.2	39.6	31.4	27.5
Error	—7.6	—12.4	5.5	—12.4	9.0	—28.0	10.0	1.0	— 4.6	—20.4	—26.8	—20.4	1.4	7.5

[a]The figures at the head of the columns are estimated speeds.

Table 2

Estimated and Actual Speeds in Miles Per Hour[a]
Series II—Subject Driving Experimental Automobile

Subject	40	50	20	50	10	70	10	30	40	60	70	60	30	20
1	32	49	31	50	10	60	15	35	44	55	60	60	35	27
2	45	54	35	48	10	63	21	35	42	54	62	55	37	27
3	36	49	34	48	6	58	10	36	48	58	66	60	35	24
4	37	43	20	47	3	55	3	24	41	50	62	55	25	16
5	32	45	25	42	2	58	3	29	40	50	63	57	42	36
6	35	45	30	48	10	65	20	38	45	55	58	55	38	30
7	41	50	25	55	20	70	15	39	47	55	69	58	41	28
8	45	50	20	50	2	67	2	40	52	55	68	58	40	25
9	40	47	18	42	2	58	2	30	38	50	58	50	25	20
10	43	54	35	52	5	68	25	34	45	60	68	62	36	30
11	36	51	32	51	5	65	8	32	45	62	64	60	46	35
12	32	45	25	51	5	64	5	30	38	55	63	54	36	28
13	43	51	21	50	2	66	2	35	38	59	64	61	42	25
14	35	45	21	45	3	60	10	28	42	54	60	58	30	18
15	37	50	24	53	3	64	5	40	47	58	68	60	36	28
16	42	51	30	51	10	65	10	32	40	55	60	58	36	31
17	37	47	22	47	2	61	2	34	42	58	65	54	30	19
18	52	58	34	58	10	70	20	35	48	61	65	58	35	34
19	38	50	26	50	5	58	18	35	44	57	65	60	39	32
Mean	38.8	49.2	26.7	49.4	6.1	61.0	10.3	33.7	43.5	55.8	63.6	57.5	36.0	27.0
Error	— 1.2	— .8	6.7	— .6	— 3.9	— 9.0	.3	3.7	3.5	— 4.2	— 6.4	— 2.5	6.0	7.0

[a]Ther figures at the head of the columns are estimated speeds.

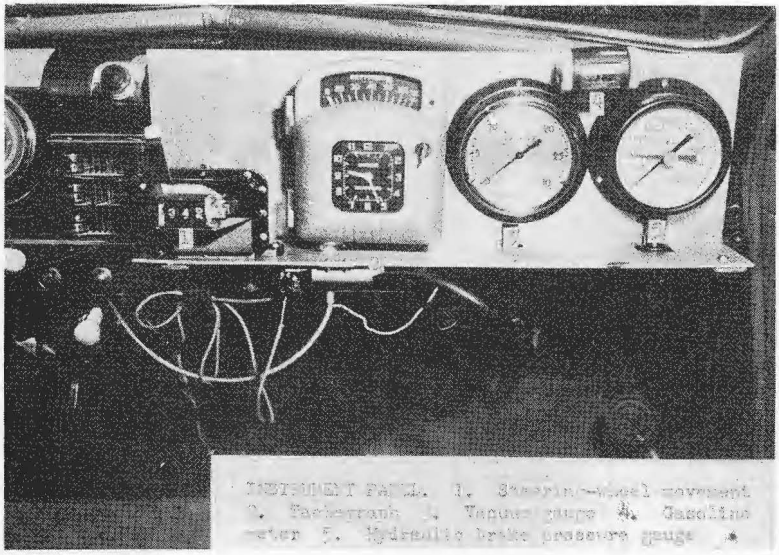


Figure 2.

Summary and Conclusions

In an effort to determine the accuracy of speed estimation on the highway and to check the validity of the Auto Trainer as a speed estimation device, a series of two experiments was made in which 19 subjects were used to determine the magnitude of error which might be expected in estimating speed. Estimates were made in the labor-

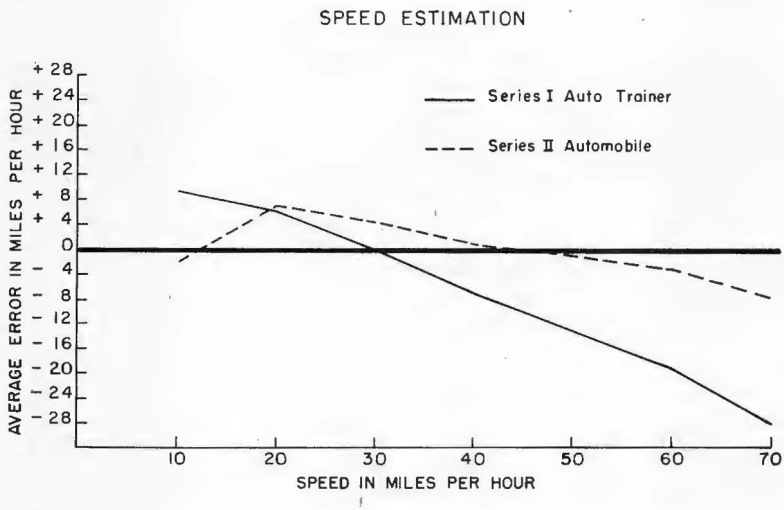


FIGURE 3.

atory with respect to the speed simulated by the Auto Trainer and on the highway while driving an automobile over a standard route.

The data thus gathered were tabulated and the average estimates as well as the average errors were calculated. The average error for each speed studied was plotted and graphs were constructed so that the magnitude and direction of the errors could be studied.

Within the limitations of the sample used, number of subjects, and nature of the results obtained the following conclusions may be tentatively drawn:

1. The graphs seem to indicate that there is a difference in the estimation of speed at various rates of travel and that the null hypothesis, that there is no difference in the estimation of speed at various rates of travel, can be rejected. The consistency of trends is the criterion of judgment.

2. The second hypothesis, that an indication of skill in speed estimation can be obtained by a laboratory device, namely the Auto Trainer, can be partially accepted in that the general nature of the graphs for estimation of speed as simulated by the Auto Trainer are similar to those for the automobile on the highway. However, the magnitude of the errors was greater.

3. There is a general tendency to underestimate at low speeds and to overestimate at high speeds.

4. The closest estimates of speed are made in the 30 to 50 mile-per-hour range.

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