METHODS OF MEASURING JUDGMENT AND PERCEPTION TIME IN PASSING ON THE HIGHWAY

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SYNOPSIS

In determining the minimum sight distance which allows safe passing, it is necessary to know the interval needed by the driver to decide whether it is safe to attempt a pass. This interval must be added to the actual passing distance or time used in calculating the minimum tangent or straight stretch necessitated. Design engineers have recognized this judgment and perception time interval and various estimates as to its magnitude have been made.

Two methods of measuring this interval are described. The first, which employs movies from directly above the test location, is capable of greater accuracy. The second method, which consists of timing by an observer with a stop watch, is rougher but easy and economical. The observer judges the physical layout to determine the beginning of the sight distance, and the driver registers his decision by stepping on the accelerator. A series of results are given for this rough check method.

The results showed two judgment and perception time figures. Both were selected to include 80 per cent of the cases. The first was 3.5 seconds and the second was 2.8 seconds. The former is more applicable to a tangent between curves and the latter may apply to other problems such as those relating to intersections.

A factor which is of interest in connection with the problem of minimum safe passing sight distance is that of judgment and perception time of the average motorist when passing another car. In a previous study of overtaking and passing distances,[1] the actual distances required were related to speeds of operation. In that study it was pointed out that for the determination of the length of tangent required to allow safe passing a clearance time should be allowed between the oncoming vehicles at the moment of completion of the pass. Also, at the start of a following or accelerative type of pass, a time allowance is necessary for the driver to estimate speeds and make his decision as to whether or not he will attempt to pass.

This "Judgment and Perception Time" has been recognized by leading design engineers and certain assumptions have been made as to its magnitude.[2] To the best of our knowledge, however, actual measurements of the time required have not previously been made.

The present paper, therefore, reports two methods which may be used for the determination of the judgment and perception time used by the ordinary driver as he rounds a curve and enters a tangent on which he has sufficient distance to pass. The first of the two methods allows greater accuracy but requires more expense and time and labor. Preliminary trials of this method have been carried out to a sufficient extent to specify the procedure which will be practical. The second method is less accurate but is

[1] Matson, T. M. and Forbes, T. W. "Overtaking and Passing Requirements as Determined from a Moving Vehicle." *Proceedings*, Highway Research Board, Vol. 18, p. 100, 1938.

[2] Barnett, J. "Needed Research for the Determination of Sight Distance." *Proceedings*, Highway Research Board, Vol. 17, p. 111, 1937.

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We are indebted to officials of the Connecticut Highway Department and to Major Johnson and Captain Generous of the 43rd Aviation Division, Connecticut National Guard for their cooperation in preliminary testing of the air method.

quick and practical and probably gives a fair approximation of the length of time in question. A series of observations from one section of the country obtained by this method will be presented.

THE PROBLEM

In hilly country where curves are fairly close together, the minimum length of tangent necessary to allow safe passing may be thought of as bounded by a curve on both ends. As shown in Figure 1A, if a driver is following a slower vehicle around the curve and entering the tangent, there will be a short distance, *ab*, during which he will not be able to start his pass although he has reached the point from which sight distance would be measured and found adequate for passing. This distance, *ab*, represents the time consumed by this second driver in pulling his vehicle slightly to the left in order to see around the vehicle ahead, plus the actual time required to perceive and judge the relationship of on-coming cars and speeds in order to decide whether or not to pass. For practical purposes, therefore, this time value represents the additional distance which must be added to the actual distance required for the pass when considering minimum passing sight distances. For our purposes, therefore, it is possible to lump the judgment and perception time and the time for lateral translation.

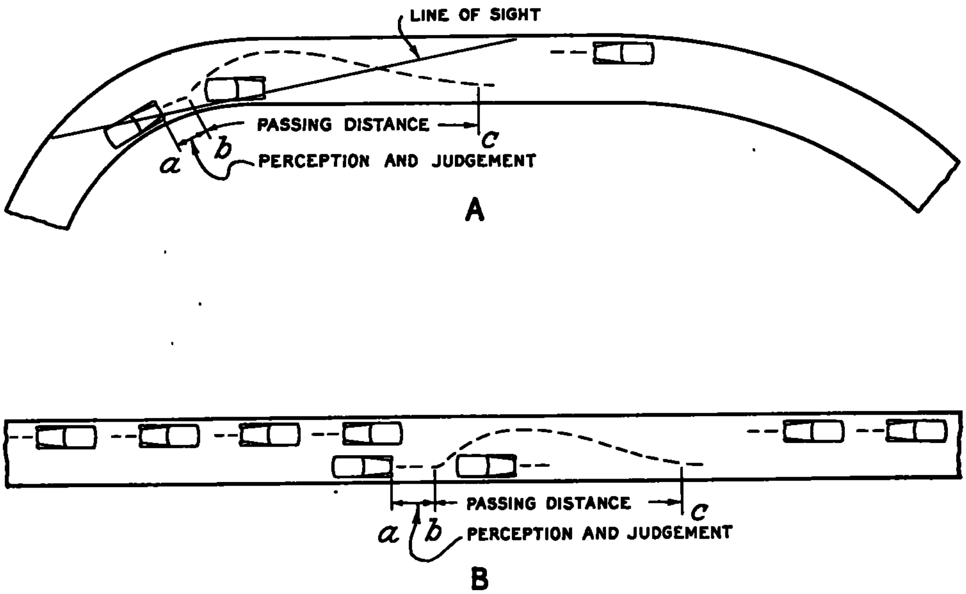

Figure 1. Measurement of Judgment and Perception Time

A—As applied to minimum sight distance between curves
B—As applied to heavy traffic conditions on tangents
ab = Lateral travel plus judgment and perception time
bc = Passing distance

A somewhat similar situation as far as the driver's reaction is concerned sometimes occurs in the middle of a long tangent, as shown in Figure 1B. The following driver has been forced back into line by a long string of on-coming vehicles. At the moment illustrated in the figure he has reached a point abreast of the last car before a gap in the on-coming line. In order to see ahead, he thereupon pulls slightly to the left and makes a judgment somewhat similar to that in Figure 1A, after which he initiates his pass.

The time corresponding to the distance "ab" in Figure 1B therefore corresponds to a similar judgment and perception time, but the lateral translation phase is very much reduced. Times so determined, therefore, would be expected to be more nearly the true perception and judgment time alone and to be shorter than those determined in the curve or crest situation of Figure 1A. They are not so directly applicable to the problem in hand as those of 1A, but may be of value for other purposes.

For a determination in situation B, it is necessary that the driver shall have been forced completely back into line behind the vehicle he is following. If he has been riding the center line in such a position that he can see ahead at all times, he will already have made his judgment and decision before the on-coming car pulls abreast and there will therefore be no zero point for the time measurement.

AIR PHOTO METHOD

A method has been devised and tried out by which determinations of judgment and perception time may be made from the air by means of a moving picture technique. A test location is chosen where drivers are bottled up and trying to pass a car ahead. It must be of such alignment that passing sight distance becomes available to the driver suddenly at a definite point. In general the method consists of taking serial photographs from directly above the test location. The plane speeds and camera characteristics must be carefully chosen. Time values can then be obtained in terms of the number of movie frames registering the movement in question and distance values may be obtained by measuring the projected picture one frame at a time.

Distance Values

In order to obtain distance values from photographs, a given dimension which appears in the photograph must be known. If the edge of the highway is sharply delineated, the width of the highway furnishes such a dimension. Delineation is best obtained by a white edge such as concrete against a dark shoulder. With the aid of such a known dimension, any slight variations in the size of the picture due to changes in altitude of the plane may be easily corrected by adjusting the size of the projected picture. Such adjustment, of course, is easily attained by moving the projector nearer or farther from the screen.

Another necessary feature is some sort of a definite landmark along the highway which appears in each frame of the movie. By referring all measurements to such a landmark, the longitudinal distances involved can be determined. A screen ruled off in squares representing distance values is of convenience for measurement.

Speed and Altitude Relationships

We will now consider relationships between speed and altitude as they bear on the type of aircraft used and related problems. Figure 2A illustrates the relationship of the minimum safe flying speed to the altitude which must be used, if the camera is to be kept fairly vertical above the vehicles being observed. Obviously a slower type of aircraft can fly lower in inverse proportion to speed with the same angular variation from the vertical.

Figure 2B illustrates the relationship of plane speed to car speed and to the parallactic error involved. From the figure it will be seen that the error *e* is a function of d_3 and of the altitude h. If we assume a car traveling at 30 miles per hour, 10 sec. of travel represents approximately 450 ft. If 1 sec. of this or 45 ft. of distance is taken as the quantity under measurement 1 percent error would be 0.5 ft. From previous studies of overtaking and passing it is thought that the time represented by ab will fall within the first 5 or 6 sec. On this basis 1 sec. would be a conservative value on which to base such a longitudinal error.

Assuming a height of 6 ft. for the vehicle and an error e of 0.5 ft. the longitudinal distance, it can be shown that

$$d_3 = 0.08h \tag{1}$$

Also

$$d_3 = \frac{1.47t(V_2 - V_3)}{2} \tag{2}$$

where t is the time of travel v_2 is the velocity of the plane and v_3 the velocity of the car. Substituting

$$h = 9.25tV_{diff} \tag{3}$$

From equation 3 the values of Table 1 have been obtained using 10 and 20 mile differential speeds. Thus, if a car is traveling 40 miles per hour and the aircraft at 60 miles per hour, in order to

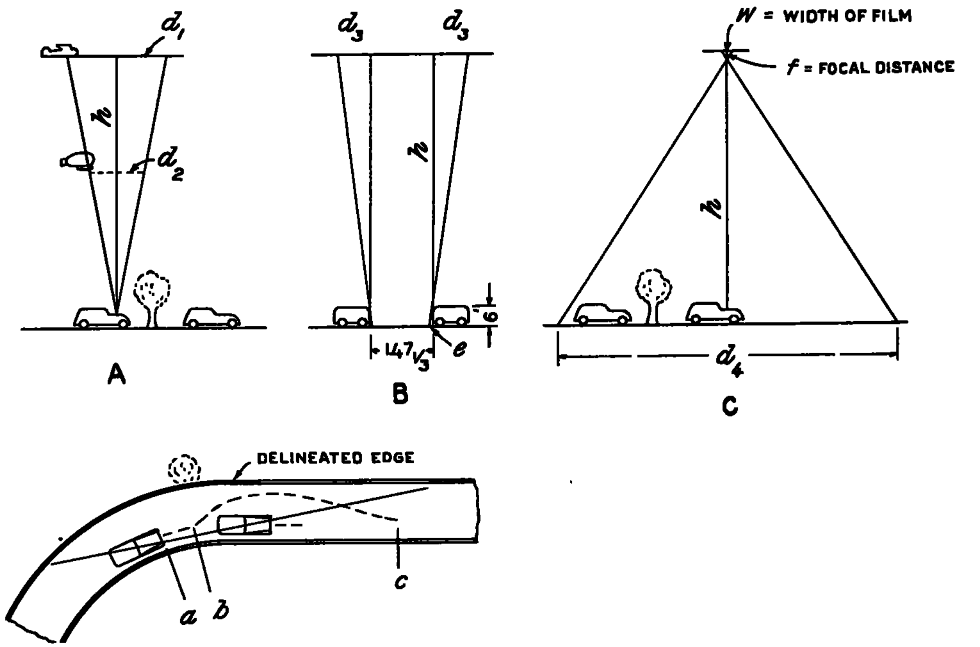

Figure 2. Measurement of Judgment and Perception Time Air Photo Method

a, b, c as in Figure 1
A—Speed relationships
B—Parallactic error
C—Camera field

TABLE 1

ALTITUDE FOR ONE FOOT LONGITUDINAL ERROR

Speed differential m.p.h.	Altitude for 1.0 ft. total error (e=0.5 ft. Fig. 2) and duration of travel of	
	1 second	10 seconds
10	92.5 ft.	925 ft.
20	185.0 ft.	1850 ft.

record the path of the vehicle within a total error of 1.0 ft. for 1 sec. an altitude of 185 ft. would be required and for 10 sec. 1850 ft. as a minimum altitude. For slower speeds of the plane the error would obviously be smaller at a given altitude. For a 10 mile differential it will be seen that anything over 925 ft. would be satisfactory. Since average speeds on most eastern highways are generally between 40 and 45 miles per hour with a range of ± 20 miles per hour it is recommended that an aircraft speed of about 40 or 45 miles per hour be used. Such a speed is safely and conveniently obtainable only with a blimp.

Since the lateral speed can be made practically zero the error in the lateral measurements will not depend to any extent upon the relative speeds of the plane and car. It will, however, depend upon the magnitude of the photographic image obtained and on the accuracy with which a projected picture can be measured. This means that the record should be made from as low an altitude as is compatible with safety and which will still give sufficient photographic field to include the amount of travel during the interval under observation.

Camera Characteristics

Figure 2C considers the camera field in relation to altitude. It will be seen that

$$d_4 = \frac{w}{f} h \tag{4}$$

where d_4 is the travel to be observed, w is the width of the film, f is the focal distance of the camera and h is altitude. Assuming the use of ordinary 16 mm. movie camera with a 1-in. lens equation (4) becomes approximately

$$d_4 = 0.64h$$

Assuming maximum of 10 sec. travel at 60 miles an hour d_4 becomes 900 ft. and the altitude 1400 ft.

It thus becomes evident that a 16 mm. camera with a 2-in. telephoto lens can be satisfactorily employed at 1000 ft. altitude as far as camera field is concerned. To eliminate fuzziness from vibration, a camera with variable shutter aperture is necessary in order to obtain a rapid exposure without the use of high speed photography and the attendant rapid use of film. Thus a clear picture can be obtained at 8 frames per second even with some vibration. A trial roll taken with an ordinary 1-in. lens from a plane moving at 90 miles per hour at 2000 ft. indicated the need for these camera characteristics. A speed of 8 frames per second gives an accuracy of time measurement approximating the minimum possible driver reaction and therefore should be sufficient. A camera with a special constant speed governor is essential.

Measurement

As previously noted, for easy measurement the film may be projected on a screen which has been marked off in distance values. Previous experience indicates that where the projection appears slightly blurry, a fairly accurate measurement may be made by spotting the picture from a moderate distance.

Devices are obtainable which allow the marking of an individual frame on the film. Such a device might be used for obtaining the time values in terms of the number of frames utilized.

Advantages and Disadvantages of the Method

The advantages of the method include easy motility, the ability to observe traffic without disturbing it, the possibility of observing the general run of drivers on the highway, and the possibility of accurately determining the point at which the sight distance at the location begins. This point may be spotted on the ground or obtained from highway department maps for given test locations.

The disadvantages consist of the expense of aircraft and film, the time and manpower necessary for measuring of records, and the necessity of a subjective judgment from the projected picture of the point at which the driver starts his pass. (Point b in Figure 1.)

Other Uses and Recommendations

It is felt that this method will be of use not only for the problem in hand but also for the measurement of the operation of vehicles by the public in relation to many other problems. For instance, the measurement of convenient values of deceleration, comfortable rates of lateral translation of vehicles and many similar problems might be attacked by the same method.

Equipment has not been available to date for the satisfactory gathering of data on the problem of judgment and perception time, except to show the feasibility of certain altitudes and the need of slow velocity aircraft. From the above considerations and the trial pictures obtained, the best combination appears to be pictures at 8 frames per second with a 2-in. telephoto lens (16 mm. movie camera) from a blimp operating at 40 to 45 miles per hour, at 1000 ft. altitude.

STOP WATCH METHOD

A simple method has been used which is probably less accurate but quick and convenient. It was noticed by accident on an inspection trip, that a driver who is following another vehicle and is intent on passing it steps down with marked definiteness as soon as he makes his decision. In other words, he steps hard on the accelerator at the point "b" of Figure 1. It is therefore possible for an observer riding with him to pick out this point from the sound of the motor and time it with a stop watch. The method thus utilizes the reverse reaction to that employed by others in measuring visibility under headlights.[3]

The observer must however determine the point "a" at which the sight distance would normally begin by means of his own judgment of the alignment and physical layout. This judgment by the observer is obviously a source of error, especially if it depends upon the estimates of one person alone. A number of observers were therefore employed. The error involved will be considered later.

Procedure

For the first group of observations, the drivers were told only that a study was being made of passing and that they were to "drive as if they were in a moderate hurry." They were therefore unaware of the details of the experiment. The observer timed the interval from a to b (Figure 1A) and also timed the complete pass with a split second stop watch. In this fashion no indication was given to the driver that interest centered on one portion of the pass alone.

Before the second group of observations the group of drivers and observers had heard a discussion of the problem and they were therefore aware of its exact nature. However, they had not yet seen the results obtained from the first observations nor discussed the magnitude of the judgment and perception time value.

A third group of observations was obtained from six women drivers "without knowledge" of the exact problem. For the first two groups of observations 19 observers and 20 different men drivers took part. The male group were for the

[3] Roper, Val J. and Howard, E. A. "Seeing With Motor Car Headlamps." *Transactions*, Illuminating Engineering Society, Vol. 33, p. 417, 1938.

most part traffic engineering fellows studying at Yale University.

Times were recorded by tabulation on a convenient card form in 0.5 sec. intervals. Columns were arranged for right curve and crest, left curve, and tangent conditions.

The observations were obtained on a two-lane highway (some concrete and some black top) between New Haven and Hartford, Connecticut, during off-peak hours of the afternoon (2 to 5 P.M.). This highway alignment includes frequent horizontal curves, and the speed of traffic probably corresponds to the Connecticut State average fairly well (40 to 45 miles per hour).[4]

Results

The results of observations made by 19 observers on the driving of 20 men and 6 women have been lumped together in order to obtain the effect of an average judgment of the location of point "a" of Figure 1A.

In treating the results a choice must be made between considering each driver as a unit to obtain an average for each person and treating each individual observation as a unit in a large total distribution. Table 2 shows the characteristic record of one driver to illustrate the fact that the record of each driver may show as wide a range as the total time range of the whole distribution. This means that the effect of different road and judgment conditions is of more importance than the individual characteristics of each driver. For this reason the observations obtained from all drivers will be combined as a single distribution of individual time determinations.

Figure 3 shows a series of such distributions lumping all observers and all drivers, but analyzing the effect of various experimental conditions. For example, Figure 3A shows observations on men drivers without knowledge of the experiment. The left hand figure represents curves and crests and the right hand one, tangents.

TABLE 2

SAMPLE RECORD OF ONE DRIVER—STOP-WATCH METHOD

Time sec.	Observed times: Right curves and crests	Observed times: Left curves	Tangents
0–.4	...	...	...
.5	4	1	1
1.0	5	4	1
1.5	2	1	2
2.0	3	1	...
2.5	...	...	...
3.0	2	...	...
3.5	...	...	...
4.0	1	2	...
4.5	...	...	...
5.0	...	...	...
5.5	...	...	...
6.0	...	...	...

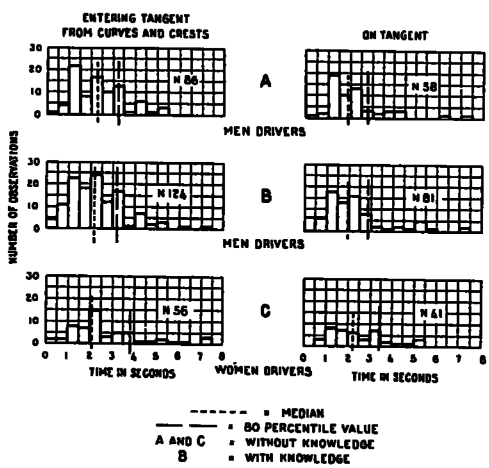

Figure 3. Effect of Knowledge of Details of Experiment, Judgment and Perception Time, Stop-Watch Method.

[4] Tilden, C. J., *et al.* "Motor Vehicle Speeds on Connecticut Highways." Committee on Transportation, Yale Univ., 1936.

Effect of Knowledge of Details of the Experiment

Before it is legitimate to throw together the results of different sets of observations, it is necessary to examine the effect of other variables. As noted above, the term "without knowledge" is applied to observations obtained when the driver knew only that a study of passing was being made. After acting as driver, he was then given an explanation and acted as observer for other members of the group. The caption "with knowledge" indicates observations taken after discussion of the problem in detail. Such discussion might conceivably influence subsequent driving behavior. However, this was not the case.

Figure 3A shows the results obtained "without knowledge" and Figure 3B "with knowledge." There is apparently less skewing of the distribution in the second case, but there is very little difference in the median and 80 percentile values. We may therefore conclude that there was no appreciable effect.

Women Drivers

Figure 3C presents the results obtained with the six women drivers. The median value is very nearly the same as that for Figure 3B, but the 80 percentile value is somewhat higher. The number of drivers is so small that too much reliance should not be placed on this series of results, but they do suggest that women drivers may require a slightly longer judgment and perception time in this highway situation to accommodate 80 percent of the group.

Direction of Curve

It was thought that possibly left curves might present a different situation than right curves and crests, since in a left curve the sight distance opens up more quickly. That is, the width of the highway, being to the left of the driver, tends to give him a continuously broader sweep of vision.

Therefore in Figure 4 these two conditions have been compared using the records of men drivers only. There is no appreciable difference in the median or 80 percentile values of these two conditions, for those time observations which were obtained. However, observers reported that it was difficult to obtain observations on left curves because in many cases the driver had made his decision by the time the sight point was reached. The fact that only 33 observations were obtained for left curves as against 91 for right curves and crests probably reflects and corroborates this report.

We may conclude, therefore, that in many cases the left curve vision opens up so gradually that the driver's decision is already made at the starting point "a," but that under conditions where oncoming vehicles or other complications necessitate a real judgment by the driver at point "a" the time involved is of the same general range and magnitude as in the right curve and crest situation.

Curves and Crests Compared with Observations on Tangents

From the considerations above it now appears valid to lump all observations for men drivers on curves and crests and similarly to lump observations on long tangents corresponding to situation B of Figure 1. Such distributions of total observations for men drivers are shown in Figure 5.

Both distributions are again definitely skewed and the 80 percentile value for the curve and crest situation is about 0.4 sec. greater than that for observations on tangents. Table 3 shows that the actual 80 percentile judgment and perception time are 3.25 sec. and 2.85 sec. respectively.

These times corroborate the expectation that more lateral transition of the vehicle was involved in the curve and crest situation than in the tangent observations. Thus the figure of 2.85 sec. probably represents an 80 percentile value for a more nearly pure judgment and perception time while 3.25 sec. is more applicable for the practical design of tangents between two curves.

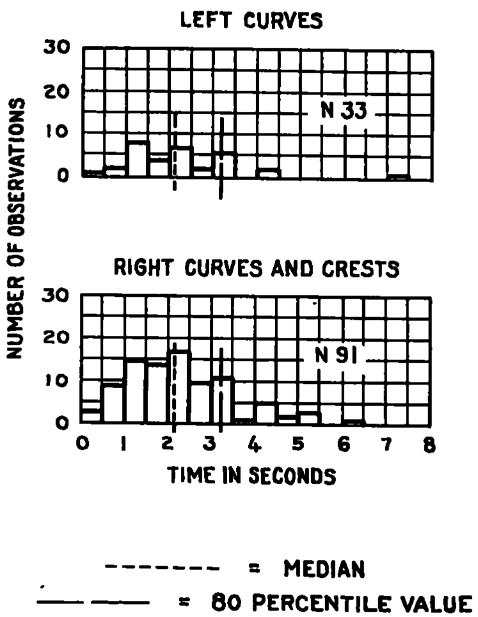

Figure 4. Left Curves Compared with Right Curves and Crests, Judgment and Perception Time, Stop-Watch Method.

In examining the mode of each distribution it should be noted that the figure shows a definite tendency by observers to record times on even seconds rather than in the half-second category. This tendency is a well known one in psychological circles wherever estimates or reports of a number of persons are

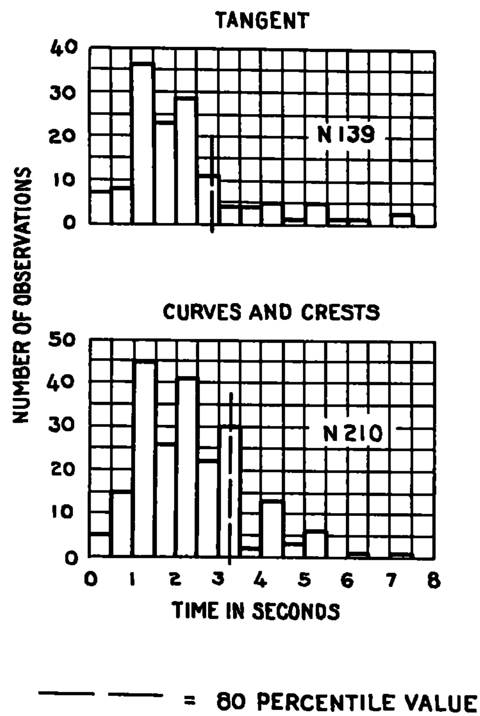

Figure 5. Tangent Compared with Curves and Crests, Judgment and Perception Time, Stop-Watch Method.

TABLE 3

Summary of Judgment and Perception Time—Stop-Watch Method

	Median		80 percentile	
	Curves and crests	Tangents	Curves and crests	Tangents
Men drivers	*Sec.*	*Secc*	*Sec.*	*Sec.*
"Without knowledge of experiment"	2.25	1.85	3 25	2.75
"With knowledge"	2.10	1.90	3.20	2.85
Total Distribution	2.20	1.90	3.25	2.85
Women drivers	2.05	2.20	3.80	3.45

involved. It is probable that the discrepancy within the 1-sec. intervals should be somewhat equalized and that for this reason the mode should fall at approximately 1.5 sec.

It is of interest that the mode should be similar in the two cases, and probably indicates that this is a minimum judgment and perception time value in this situation. Values below 1 sec. are relatively infrequent and fall in the range which is known to represent brake reaction times. Therefore these short times probably represent judgments which were partially made before the observed zero point on the highway was reached.

Sources of Error in the Stop-Watch Method

Two main sources of error are inherent in the stop-watch method. The first of these is that the observer's own perception time is involved. However, this is not so serious an error. The observer must judge the location of point "a" in terms of the physical layout and alignment. However, he makes this estimate in a relatively gradual manner since he can observe the unfolding outline of the curve or crest, and start his watch at the first point which would give a clear, safe passing sight distance. Thus all that is involved is his simple perception and reaction time at this point. It is known that ordinary stop-watch reaction times run about 0.1 sec. and this error should therefore be negligible in our result.

A more serious error rests on the fact that the judgment of the actual point "a" may involve a very substantial distance error. Such errors might be made in either direction and if a sufficiently large number of observers and observations is involved, a normal distribution of these errors should be obtained. If so, this error should balance out.

Adequacy of the Sample

Although the number of *observations* should be sufficient to give a stable determination, it must be borne in mind that our results represent a relatively small number of *drivers*. They also represent a sample from one type of terrain and fairly heavy traffic conditions.

Our observers were probably pretty well qualified to make the determinations in the second group of observations, Figure 3. In the first group they may not have been quite so well qualified as observers, but they were better qualified as a representation of the general public since their knowledge was less complete. In any case this factor does not seem to have been of great importance.

The drivers in our sample were probably better than average on the whole since most of them were professionally interested in traffic.

For these reasons larger samples of observations on the general driving population should be obtained by the air photo method described in the first part of this paper. Furthermore, a sample should be obtained for different conditions of traffic density and terrain in different parts of the country if a more accurate and exhaustive determination is desired.

Our sample should, however, be adequate to give an approximate idea of the time values involved.

Comparison with Reaction Times

As noted above, the modal judgment and perception time is seen from Figure 5 to fall somewhere near 1.5 sec. This gives us a value which may perhaps be compared with certain average times which have been obtained in other studies. Thus an average complex or choice reaction time with steering and brake apparatus has been determined at approximately .60 to .75 sec. and a simple reaction time at about .5 sec.[5] A modal judgment and perception time of about

[5] DeSilva, H. R. and Forbes, T. W. "Driver Testing Results," Bureau for Street Traffic Research and W. P. A. of Mass., Boston, 1938.

1.5 sec. would seem to be a reasonable continuation of this series of average times.

However, it should be pointed out again that the 80 percentile value rather than the modal value should be used where possible for design and control calculations.

Practical Application of Time Values

It has been pointed out elsewhere that the use of the 80 percentile value takes care of the large proportion of the general run of drivers.

Therefore, for the determination of minimum passing sight distance and minimum length of tangent between curves, the value of 3.25 sec. obtained from men drivers would seem to be applicable. The fact that the judgment and perception time from the women drivers was approximately half a second longer suggests that 3.5 sec. would not be too great a value to adopt where practically feasible from other considerations. For a 50 mile per hour design speed, such an interval adds 258 ft. to the actual passing distance. The 80 percentile passing distance for this speed was shown to be about 1200 ft. in our previous study.[1] An addition of over 20 percent is necessary at this speed, therefore.

Judgment and perception time may be viewed as a constant value, and passing times were shown to be proportional to speed. It follows that the proportion added by the judgment and perception time will be greater at lower design speeds. The shorter judgment and perception time of 2.8 which represents the 80 percentile point for the tangent observations may be of interest in other problems connected with design and control devices.[6] It is probably closely related to the time for complex judgment which is necessary at intersections and in similar traffic situations where no extra interval for lateral translation is involved.

Both the intervals of 3.5 sec. and 2.8 sec. are somewhat greater than some estimates which have been made for these values.

SUMMARY

1. Two methods were described for measuring judgment and perception time in passing. The first, an air photo method, allows greater accuracy, while the second is a rough check stop-watch method.

2. From a consideration of relative speeds, altitude and camera characteristics as well as results of exposing a trial roll at 2000 ft. altitude, the use of 16 mm. movies at 8 frames per second, with a 2-in. telephoto lens at 1000 ft. from a blimp operating at 40 to 45 miles per hour was suggested.

3. The rougher method consisted of timing the judgment and perception time with a stop-watch. The observer riding in the car judged the point at which sufficient sight distance became available from his own observation of the physical layout. The time at which the driver had made his decision to pass was almost invariably indicated by "gunning" of the motor.

4. Nineteen different observers were employed and a total of over 200 observations to minimize errors in determining the sight distance zero point. This error would be expected to balance out.

5. Results from the rough check method indicated that when drivers follow a vehicle around a curve and attempt to pass on entering the adjoining tangent, a judgment and perception time of 3.25 to 3.5 sec. should be allowed for them to judge speeds and make their decisions. This figure included 80 percent of the observations. Twenty men and six

[6] Barnett, J. "Needed Research for the Determination of Sight Distances at Intersections." *Proceedings*, Highway Research Board, Vol. 18, p. 76, 1938.

women drivers were tested. The latter tended toward somewhat longer time values.

6. Part of this figure undoubtedly represents lateral travel of the vehicle. A judgment and perception time (80 percentile) value of 2.85 sec. resulted where less lateral travel was probably involved. This figure is probably more nearly a measure of judgment and perception time alone and may be of value for other traffic problems.

7. For more accurate determinations, observations should be made on a larger number of drivers under different traffic densities in different parts of the country by the air photo method.

8. The 3.5 sec. time when added to the actual passing distance at 50 miles per hour represents the addition of approximately 20 percent in distance. This interval is of importance in the computation of minimum safe passing sight distance, a factor controlling to a large extent the desirable minimum length of tangent between curves on highways. The importance of the interval has been recognized by leading design engineers, but measurements of it have not been previously obtained.

DISCUSSION ON METHODS OF MEASURING JUDGMENT AND PERCEPTION TIME

Dr. Bruce D. Greenshields, *College of the City of New York:* The methods of measuring judgment and perception time in passing on the highway, given by Dr. Forbes, bring to mind the method used in Michigan in 1933 to study the minimum spacing between vehicles. In this study a movie camera arranged to take pictures at intervals of about 1 sec. was used. The exact interval found most convenient was 1/88 of a minute, for the distance in feet traveled during this time interval equals the speed in miles per hour. The method is fully described in the Proceedings of the Highway Research Board, Vol. 13, pages 362-396 (1933).

During the past summer, in Ohio, in connection with a study of the "Marking of No-Passing Zones," some time-motion pictures were taken. For ease in analysis, such pictures should be numbered. This was accomplished by including in each picture a view of a Veeder-Root Counter which was mounted about 20 in. in front of the camera and brought into focus by means of an auxiliary lens. This counter was actuated by the same electric-release that operated the camera. The electric release timer and the counter were operated continuously, while the camera was switched on only while vehicles were passing. This conserved film. Figure 1 shows the bulletin board used to identify each film and two consecutive pictures. The camera was an Eastman Cine Kodak Special, 16 mm. The electric release is made by the Eastman Company.

The point at which the driver starts to accelerate, as explained by Dr. Forbes, gives the point at which his perception-reaction is completed. This point, at favorable locations, can be found by means of the camera, although it is not mounted directly above the roadway. If the field of view is extensive enough, a view from the side gives the speed or change of speed.

An unobstructed view from the inside of a curve, such as is shown in Figure 1-A of Dr. Forbes' paper, would be especially favorable for pictures taken from the ground or a slight elevation, such as might be obtained from a truck tower. Located on the inside of the curve, the distance from the camera to any point on the roadway would be about the same. The displacement of the cars against the background gives the speed so that the movement of the camera does not affect the accuracy of the observations if the shutter opening is made brief enough to avoid blur. This means that the camera could be rotated on its tripod to keep the car or cars in view.

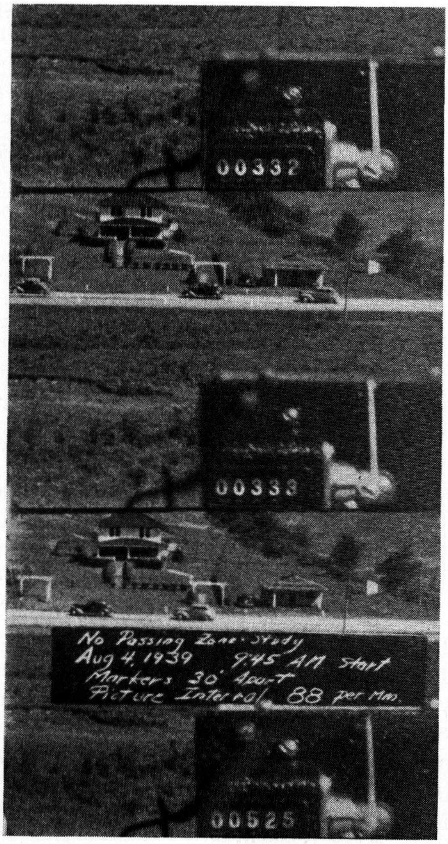

Fig. 1

The position of the vehicle on the opposite lane at the instant of passing can be obtained from its speed when it appears in the pictures. This idea is explained in "Distance and Time Required to Overtake and Pass Cars," PROCEEDINGS OF THE HIGHWAY RESEARCH BOARD, Vol. 15, pages 332-342 (1935).

It is pointed out in the 1933 paper that the spacing between vehicles depends upon reaction time, or more correctly, on perception-reaction time. The average time was found to be about $\frac{3}{4}$ of a second. A re-study of the data shown on page 391 of the 1933 Proceedings, gives the 80 percentile value as 2 sec. at 5 miles an hour, and 1.3 sec. at 39 miles an hour. These values agree closely with the median values given by Dr. Forbes.

DOCTOR FORBES: The discussion by Dr. Greenshields raises an interesting point as to the relationship of this time interval to that previously found for the spacing of vehicles on the highway. Dean Johnson, Thompson and Hebden, Greenshields, and others, deserve credit for the use of moving picture analysis of various phases of traffic behavior, and Dr. Greenshields especially for introducing reaction time factors.

Although the method reported by Dr. Greenshields in his 1933 article was considered by us for the judgment and perception time problem, it presented certain difficulties. With a camera operated from a position on the ground at one side of the highway and trained at right angles to the highway, it is very difficult to record certain very important items. For instance, a driver may be so placed that he can look down the center line of the highway and in this case there can be no determinable zero point for his judgment time. Again, the placement of vehicles ahead of him may be such that his view is completely blocked for a long period of time and therefore he cannot be expected to make any judgment as to whether or not he can pass until such a situation has cleared up. A third difficulty is that some drivers accelerate rather slowly, but do turn their vehicle laterally in starting to pass. If the motor is gunned even momentarily, it can be heard by an observer riding in the car, but it would be rather difficult to detect a slow acceleration accurately from the recorded motion of the car. In place of such a determination of acceleration, the lateral path of the vehicle can be obtained from our air photo method and we feel that this would be the more reliable.

The most important point, however, regards the conditions of observation in the 1933 study made by Dr. Greenshields of the spacing of vehicles. If our understanding of this report is correct, these times were obtained for the spacing of vehicles as they were operating on open highway. This means that the drivers may or may not have been trying to pass the car ahead, and the supposition is that the majority of them were merely following in line.

These spacings were shown in his report to be explainable in terms of the length of the vehicle plus a 5-ft. spacing between vehicles (found at zero velocity), and an added spacing when moving at moderately high speeds which corresponded to a brake reaction time of 0.75 sec. (p. 392-394). This interpretation of the spacings which were found seems valid and corroborates the assumption that no judgment of the type we are discussing in our paper was included in the time interval. (Complex reaction and judgment times are known to be longer than ordinary brake reaction time.) It therefore does not seem allowable to re-interpret the time values obtained from the spacings of Dr. Greenshield's study as judgment and perception times.

If the judgment and perception time necessary for the driver to make up his mind about a passing situation were included in Dr. Greenshields' experimental conditions, his spacings in terms of time should have been considerably greater. In our determinations on tangents, for instance, we sometimes obtained 2½ or 3-sec. times for the driver to make up his mind and yet, during this period, he might be following the car ahead at a headway as short as 1.0 sec. This is another indication that the spacing of ordinary traffic represents a different condition than does the situation where a driver is trying to pass and requires a certain amount of time to make up his mind whether or not it will be safe. The two time values would, therefore, not be expected to be comparable.

Incidentally, it seems a little hard to justify the comparison of an 80 percentile figure from the 1933 study with a median (50 percentile) figure from our determinations. It will be noted that our 80 percentile values were 2.8 and 3.25 sec. respectively—rather larger than Dr. Greenshields' 1.3 sec. value.

In summary, it seems that the conditions under which Dr. Greenshields' 1933 time values were obtained do not satisfy those for the determination of judgment and perception time and that the particular form of moving picture recording which he used would not be as suitable for our purposes as the methods suggested. However, the question of the relation of judgment and perception time to stopping brake reaction time and the spacing of vehicles is of interest and we are grateful to him for raising the question. The two psychological functions involved are distinctly different.