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Bulletin 152

Driver Characteristics

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Contents

Personal Characteristics of Chronic Violators And Accident Repeaters

LEON BRODY, Ph. D., Director of Research, Center for Safety Education
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● THE New Jersey Accident Prevention Clinic was set up by the Division of Motor Vehicles in October of 1952. Its purpose was to test and examine poor drivers of various types, as indicated by New Jersey's point system and other data; to identify personal characteristics associated with their driving records; and to inform the drivers examined of any important deficiencies noted. The Center for Safety Education at New York University was invited to provide technical guidance in this program.

In more than two and a half years of operation, well over 5,000 referrals were interviewed and tested at the clinic. Of this number, complete and usable IBM record cards were obtained for 941 accident repeaters, 809 chronic violators, and 424 control subjects with good driving records (the latter to provide a basis for evaluating test results for the chronic violators and accident repeaters).

For justifiable conclusions, it was necessary to equate the three groups with respect to driving exposure, education, and income, and to control for age differences, so that any significant test findings might be attributed to basic differences between the groups rather than to the variables mentioned. As a result of this equating, the study populations were further reduced to 375 chronic violators, 133 accident repeaters, and 124 control subjects. Thus, the final total of 632 cases represents carefully selected samples of the original populations. All of these cases are between 26 and 57 years of age. Some 450 cases under 26 years will be the subject of a special report at a later date.

In the present report, then, the concern is with the significance of the findings for basically comparable groups of "good" and "bad" drivers between 26 and 57 years of age. The test of significance in all cases was the statistical device known as chi square, except that critical ratios were employed in evaluating reaction time data. Wherever the term "significant" is used, it refers to a confidence level of 5 percent or better. The findings were as follows:

Function(s) Examined	Finding
Simple reaction time	No significant difference between control subjects, chronic violators, and accident repeaters in 5 out of 8 comparisons of subjects by age groupings [1]; two such comparisons favored the control subjects, one the accident repeaters.
Complex reaction time	No significant difference between control subjects and chronic violators in 7 out of 8 age-group comparisons.
Glare recovery time	Mixed results throughout, probably due to test invalidity. The test produced a tri-modal distribution (clusters of good, fair, and poor scores) for all three categories of subjects.
Depth perception (day and night tests)	No significant difference between control subjects, chronic violators, and accident repeaters, probably because of questionable test validity.
Field of vision	Control subjects significantly better than chronic violators in one or the other eye; no significant difference between control subjects and accident repeaters.
Visual acuity	No significant differences were noted between control subjects and accident repeaters. However, chronic violators as a group had significantly better visual acuity than the control subjects as a group!

[1] 26-33, 34-41, 42-49, and 50-57 years of age.

Function(s) Examined	Finding (continued)
Personal adjustments and personality trends (Sacks Sentence Completion Test)	There were found in this highly complex and difficult field of testing, 11 significant differences that tended to favor control subjects over accident repeaters, compared to 3 favoring accident repeaters over control subjects. However, 14 significant differences were found that tended to favor chronic violators over control subjects, compared to 2 that favored control subjects over chronic violators! Outstanding areas of difference in these two sets of comparisons included: attitude toward parents, guilt feeling, fears, and reality level. Comment: Originally, it was reasoned that in general the control subjects would be better adjusted in their everyday living than the accident repeaters and chronic violators. Since the literature strongly supports this hypothesis, the mixed findings just noted suggest that the Sacks test is not suitable for these particular purposes because of inherent subjectivity—or else chronic violators tend to respond to such test items in some peculiarly defensive manner.

A few other findings of interest were derived from intake interviews and biographical questionnaires. It was thus ascertained that 93 percent of the control subjects were married as compared to only 73 percent of the chronic violators and 79 percent of the accident repeaters. The differences, though not very large, are statistically significant.

Another finding of importance related to job stability. Intake interviews and questionnaires showed that control subjects have been significantly more stable in this respect (that is, did less job-changing) than chronic violators during the five-year period preceding their examination at the clinic. However, no significant difference was noted between control subjects and accident repeaters.

Three general conclusions can be drawn from these findings and from supporting findings of other research studies:

1. The problem of safe, lawful, and courteous driving is primarily a problem of emotional makeup and social adequacy. So-called psychophysical functions (reaction time, glare recovery time, etc.) do not, per se, differentiate between good and bad drivers. The latter may excel in these functions in many instances, while the former may occasionally be inferior without jeopardy to their driving records.

2. With regard to the psychological (as distinguished from the psychophysical) factors noted above, other research studies indicate that the following specific characteristics tend to be evidenced by chronic violators and accident repeaters: They are apt to be aggressive and intolerant of others. They tend to resent authority. They are inclined to have an exaggerated opinion of their importance and their abilities. They are likely to be lacking in responsibility and often act impulsively, on the spur of the moment. The basis for such characteristics is likely to be obscure. Just as eight-ninths of an iceberg lies below the surface of the water, most of the factors and forces that shape an individual's personality are hidden in his background, often in early childhood experience.

3. Obviously, here is an extremely difficult and complicated problem. It is not surprising, therefore, that work at the New Jersey Clinic and similar work elsewhere have not produced simple formulas for detection or correction of problem drivers. While the general importance of personal adjustments and personality trends are indicated, it cannot be said with assurance: use this or that test in screening drivers for licensing purposes or in driver reexamination. But the development of such tests remains one of the prime needs and objectives. Experiments toward that end will be continued.

Dynamic Visual Fields*

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It is estimated that an obstruction to vision contributed to one out of every eight motor vehicle accidents. In these, vision was obscured by objects on the car in 40 percent of the cases and stationary objects such as trees and buildings in 30 percent of the cases; the remainder were other cases—some moving, some parking, and a few instances of glare. To these must be added an undetermined number of cases where, through inattention, distraction, or other cause, the visual stimulus which fell upon the eye failed to "register;" that is, it failed to be perceived and interpreted. Knowledge of man's capability for viewing in terms of extent when operating a moving vehicle, his viewing habits or patterns, and his response behavior, is essential as the basis for specifying and providing for human requirements for vehicle design, highway planning, and driver training.

● THE reports which appeared both in the 1954 and 1955 edition of Accident Facts emphasized the relative importance of visibility in vehicular safety. An obstruction to vision was considered to have contributed to one out of every eight motor vehicle accidents. In these, vision was obscured by objects on the car in about two-fifths of the cases and by stationary objects such as trees and buildings in a third of the cases. The remaining one-quarter involved obstruction to vision by moving or parked cars and in a few instances interference with vision by glare. To these must be added an undetermined number of cases where, although visual obstructions were not involved, the object which should have warned the driver failed to register in his consciousness because of inattention, distraction or other causes.

In analyzing the visual factors contributing to accidents, the visual stimulus from a potentially hazardous object (a) may not reach the eye because some opaque object on the car or on the highway blocks the image that would otherwise have fallen on the retina; (b) may not constitute an adequate stimulus because of the characteristics of the hazardous object and the limitations of man's visual equipment; (c) may not fall upon the retina because the vehicular operator is looking elsewhere during a critical period; or (d) may form an image of adequate energy on the retina but fail to register—that is, may fail to be perceived and interpreted. Visual requirements for safety, then, relate to the car, the driver, and the road.

While there is nothing new in the concept that the machine, the highway and the man may each contribute to an accident, such a classification fits in well with a method of approach to the study of accidents which is currently being used by some biologists. Since accidents constitute a mass health problem, the biologist veiws them much as he would an epidemic and considers that accidents result from interaction of the agent (the vehicle), the environment (the highway), and the host (the driver). The approach is not only useful here, but also serves to emphasize the thesis of this report: since accidents result from an interaction of three components, the prevention of accidents due to some failure of the visual warning will require the application of remedial measures to the car, the highway, and the man.

Measurement of Opaque and Transparent Areas Affecting Vision

The first consideration is the agent (the vehicle). From the driver's seat—even under optimal conditions of a clean windshield, fair weather and good illumination—the sideposts, dash, hood, top, sides and floor of the vehicle markedly limit what can be

* The studies herein reported were conducted under the sponsorship of the Commission on Accidental Trauma of the Armed Forces Epidemiological Board and were supported by the Office of The Surgeon General, Department of the Army.

seen. The arrangement for visibility and the design of structures will vary from car to car. There must be some means of describing the transparent areas and the opaque obstructions as a basis for interpreting accident reports, comparing makes and models, and evaluating new and "improved" visibility provisions. Subjective evaluation can no longer be accepted where, for example, a 1956 model is judged to provide better visibility than a previous model. Simple measurement and comparison of the total glass area is unacceptable not only because of the sloping and curved windshields, but also because it fails to give the locations of the opaque structure. The procedure here has been to employ a system of measurements and calculations which provides for evaluation of visibility from within the vehicle on an absolute basis, rather than a mere subjective comparison between designs. Briefly, the procedure is to measure the angular positions of points along the boundary of the windshield and side windows as seen from the eyepoint of the driver, to determine from a graph of these data the total solid angle intercepted, and to score this with respect to the total useful visual field. The measurements are made with a goniometer (Figure 1) which the authors developed to obtain data on automobiles (Figure 2), buses, and trucks. The values are plotted on a modified polar coordinate graph paper developed by P. J. Sutro especially for this purpose (Figure 2A). The special paper gives an equal area projection such that the area of any region on the graph is proportional to the solid angle. The areas for vision shown on the plot are measured directly with a planimeter. To convert the results to solid angle (in steradians) the measured area is divided by the scale factor; in out plots there are 10 sq in. per steradian. The details of measurement and calculations are described in earlier reports (1, 2). The results for the foregoing example (Figure 2) are given in Table 1.

Evaluating and Scoring Visibility. Once the data are obtained, how are they to be interpreted? Since design for visibility is specifically directed toward fulfilling human

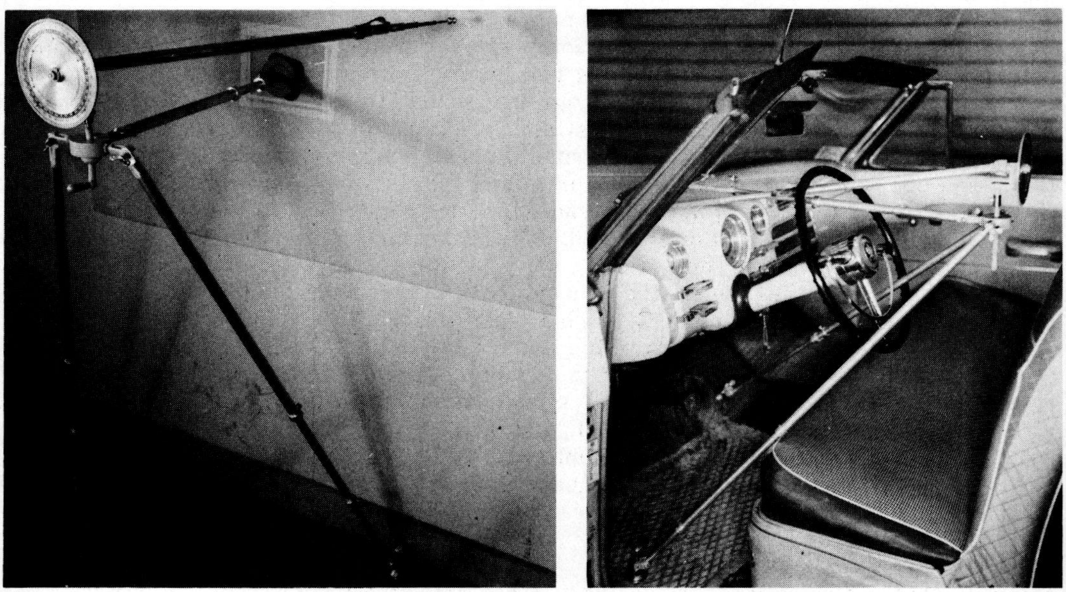

Figure 1. Vehicle goniometer showing the angle plate, the telescoping rod and supporting structure. There is also a sighting attachment for the goniometer (with crossbar and circle-dot sights and double mirror system which permits viewing at right angles to the sighting line) which can be readily attached and used in place of the telescoping rod. At right are shown details of mounting in an automobile, with the reference center of the instrument located at the eye-position of the driver.

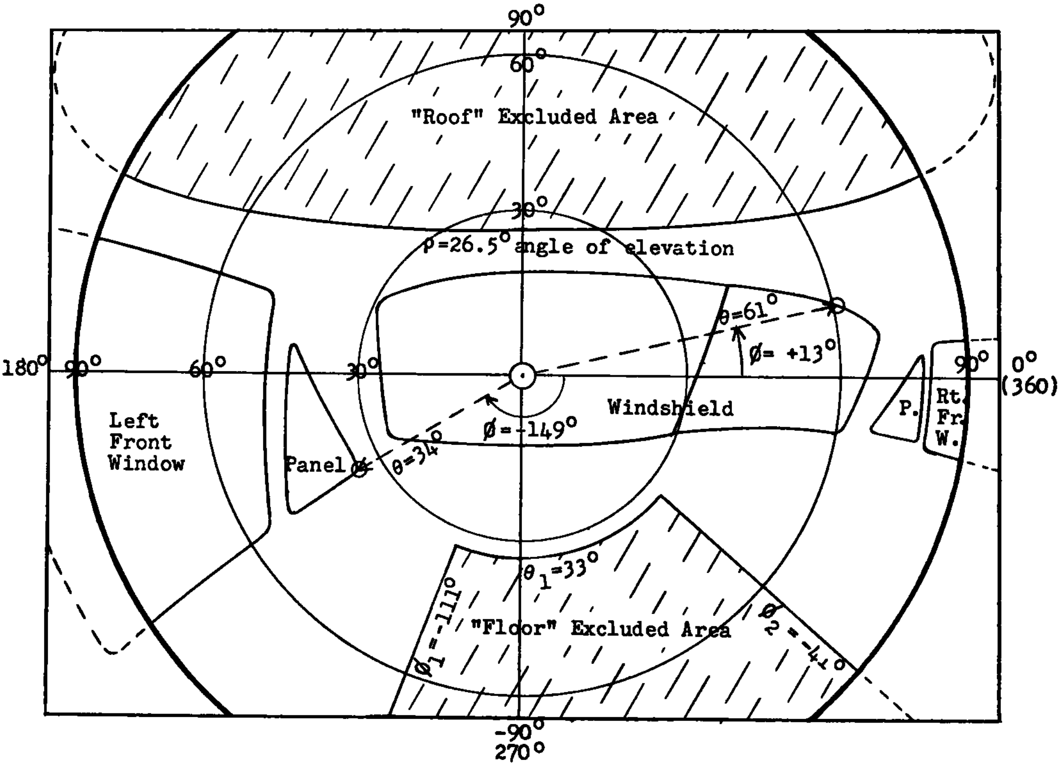

Figure 2. Diagram illustrating the location of the various windows and excluded areas plotted in Figure 2A (as an example), and showing how angle data are plotted on the special graph paper (2A)(to give an equal-area polar projection). For instance, the bottom front (b.F) corner of the left front panel is at ϕ=-149°, θ=34°. The plotted position of this point (circled) is located by moving outward along the radial line for θ=-149°(as indicated by the dashed arrow) until it crosses the circle for θ=34°.

requirements in a driving situation, the total area of visibility provided by the vehicle can be compared with the total area which man would be capable of viewing if he were sitting in space with no obstructions limiting his vision. There is, however, a practical consideration to the latter; not all of the area which man is capable of viewing constitutes a necessary or even useful area of vision for driving. A practical basis or reference value can be taken excluding certain non-essential areas (Figure 3). This is the total area which man is capable of viewing less: (a) the "floor" area directly beneath the vehicle, bounded by the four wheels (since once in this area, the object can no longer be avoided); and (b) a "roof" region overhead, above a critical angle of elevation (beyond which upward vision is not a vehicular safety factor).

The area score for a vehicle would then be the ratio of the "useful" region that can be seen from the vehicle (measured as the solid angle of the total useful area; that is, the windshield, side windows, etc.) to a reference solid angle defined as the total useful region which man could scan; that is, the solid angle of the total human visual field, excluding areas corresponding to (a) and (b).

The total solid angle, in itself, is no true index of the effectiveness of the provisions of visibility. Not only must the area be sufficient, but certain critical areas must be completely free from obstruction, while in other important but sub-critical areas, structures up to 1.5 to 2.0 in. wide can be tolerated. The critical area is defined as the region through which is to be seen the road and its shoulders ahead of the front wheels. The sub-critical areas might be suggested, but could not be factually supported at this time. They are determined by potential collision courses with moving and with stationary objects which lie within the areas that could be viewed by man under normal conditions of operation.

Windshield Wiper Performance and Visibility. If there is rain or snow, only a small portion of the transparent area provided by design is cleared by the windshield wipers; this may be less than 30 percent of the total transparent area provided. Other glass areas to which rain or snow may not adhere and portions of the areas cleared by windshield wipers may be fogged in spite of heaters and defrosters. A "lighthouse" diagram illustrates the obstructions to vision (a) from structure and (b) from areas which are not cleared by standard wipers in a 1954 sedan (Figure 4). Photographs taken through the windshield of this car show the road and other areas as seen through the standard wiper pattern by tall, medium and short drivers (Figure 5). It is to this aspect of the vision problem that the attention of the design engineer is invited.

Man's Viewing Habits and Capabilities. Knowledge of the area which man is capable of viewing is necessary to predict whether a design change will be of benefit. In order that the data be pertinent, what a man can see under normal conditions of driving must be considered (that is, with moderate head and eye movement) rather than the visual fields determined by usual clinical examination where the head is fixed, one eye is closed, and the eye under test is focused on a fixation point directly ahead. A reasonable set of conditions for moderate head and eye movements would be with the head moving 45 deg to the left and right and 30 deg up and down, and the eyes moving 15 deg

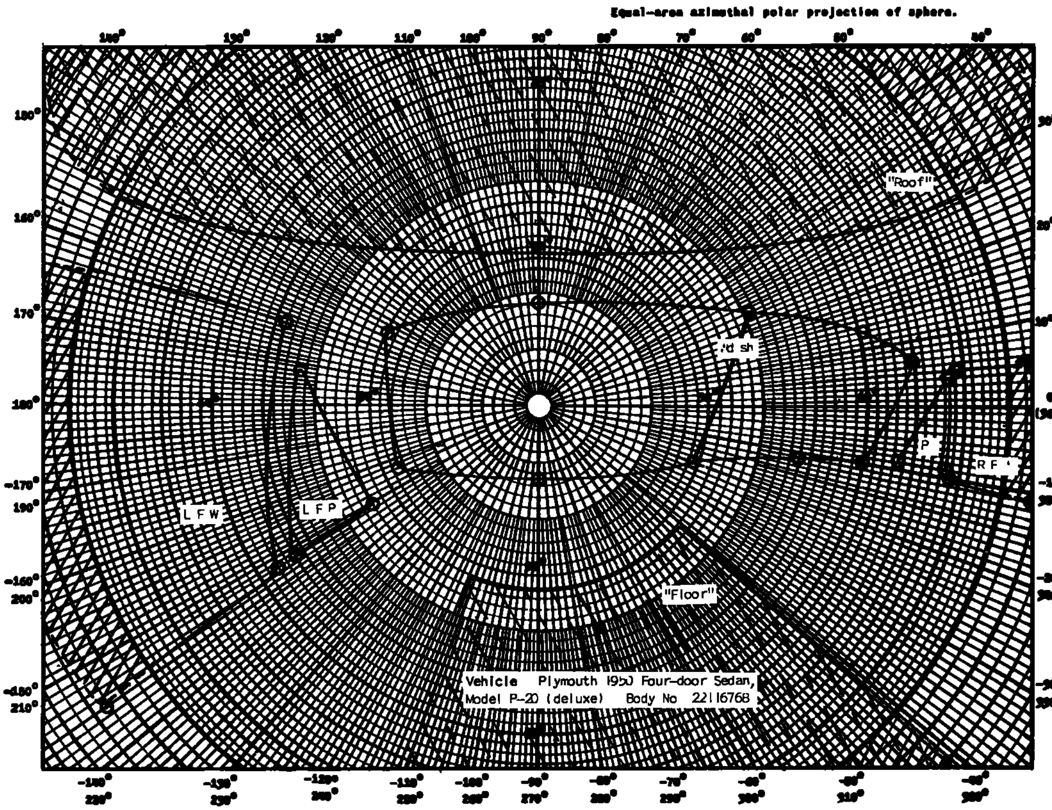

Figure 2A. Forward hemisphere - Plymouth P-20 sedan. Equal-area polar plot of windshield and side windows, as well as excluded areas (dashed shading), for the front half ($\theta \leq 90°$) of the vehicle-as seen from the driver's eye-point. On the special graph paper, the co-latitude θ is plotted radially (scale non-linear), and the azimuth angle ϕ counter-clockwise. The pole at the center is the forward horizontal line of sight (the prime axis) and the region outside the heavy circle (θ=90°) is in the rear hemisphere.

TABLE 1

RESULTS ON PLYMOUTH SEDAN

Plymouth 1950 Four-Door Sedan (deluxe), Model P-20.

Scores calculated from windshield-window and reference solid angles, which are given in steradians (Ω) and in percent of sphere ($\Omega/4\pi$) and broken down into component parts "Front half" refers to values for forward hemisphere alone (where $\theta \leq 90°$), "entire car" to sum of results for both hemispheres. Thus the differences between these two columns are the results for the rear hemisphere ($\theta \geq 90°$) for all tabulated quantities except the (final) score

Window or Area		Entire Car Ω (sterad)	Entire Car ($\Omega/4\pi$) %	Front Half Ω (sterad)	Front Half ($\Omega/4\pi$) %
Excluded area (solid angle)	"roof"	3 480	(27 7)	1.740	(13 8)
	"floor"	2.052	(16 3)	1 031	(8.2)
	Total: Ω_{ex}	5 532	(44 0)	2.771	(22 1)
Reference solid angle $\Omega_{rf} = 4\pi(\text{or } 2\pi) - \Omega_{ex}$ ≠		7.03+	(56 0)	3.51	(27.9)
Windshield (total)		0.737	(5 86)	0 737	(5 86)
Left front panel		.078	(0 62)	078	(0.62)
Left front window		.906	(7.21)	.580	(4.62)
Right front panel		.023	(0.18)	023	(0.18)
Right front window		.098	(0.78)	058	(0.46)
Left back window + panel		.212	(1.69)	-	-
Right back window + panel		104	(0.83)	-	-
Rear-view window		114	(0.91)	-	-
	Total Ω_w	2.27	(18.1)	1 48-	(11 7)
Score. Ω_w/Ω_{rf}		32 3%		42 0%	

≠ Ω_{rf} is found by subtracting the forward hemisphere Ω_{ex} from 2π for the "front half," or the whole Ω_{ex} from 4π for the "entire car "

Note $\Omega/4\pi$ (in percent of sphere) merely expresses Ω in other units

to the right, left, up, and down from a central position in the orbit. According to the data of Hall and Greenbaum (3), under such conditions a man may see 155 deg to the left and right, about 90 deg up and 112 deg down. Peripheral limits which could be viewed simultaneously with both eyes would be out to 105 deg left and right; the 50 deg beyond that which can be viewed monocularly is important for gaining information warning of the presence of objects, especially those in motion. Detailed data are shown in Table 2. The corresponding total solid angle viewed has been calculated, with the results given in Table 3. This shows that under conditions of moderate head and eye movement, the solid angle of the visual field is 9.48 steradians or about 75 percent of a sphere. Closed cars may not provide total transparent areas which are even one-third of this value, so that apparently man's capabilities are not likely to limit the benefits he might gain from designs which may appear in the next few years.

Collision Pathways and Stopping Distances. T. W. Forbes wrote in 1951: "Ever notice, when driving, that another vehicle was tending to maintain a fixed

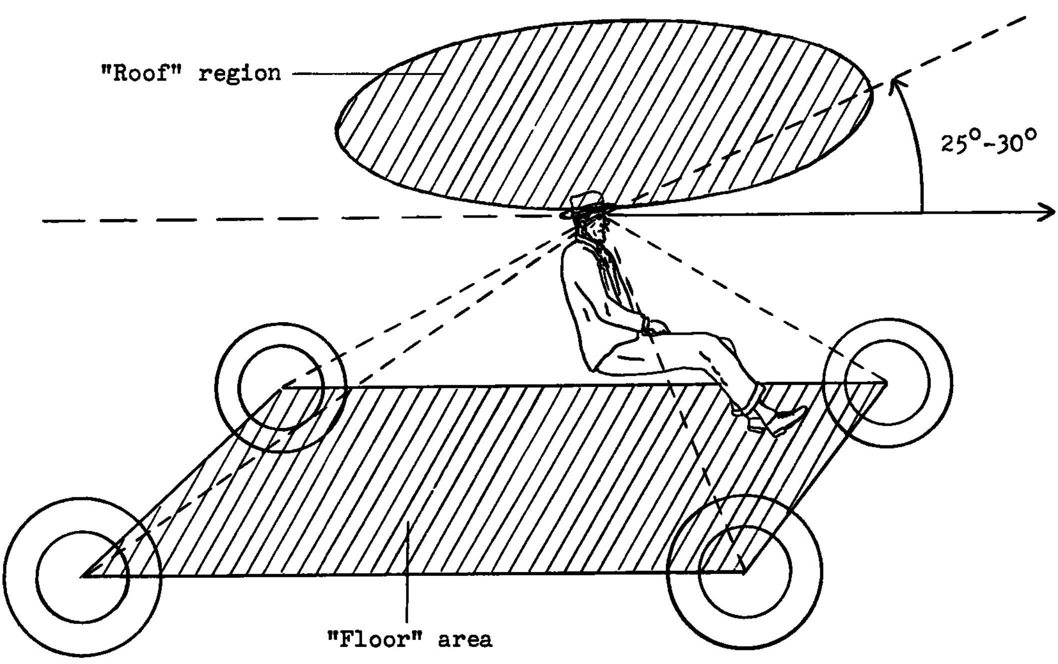

Figure 3. Regions which do not contribute to the areas of vision useful for vehicular operation (shaded areas) are excluded from the solid angle employed in scoring vehicles.

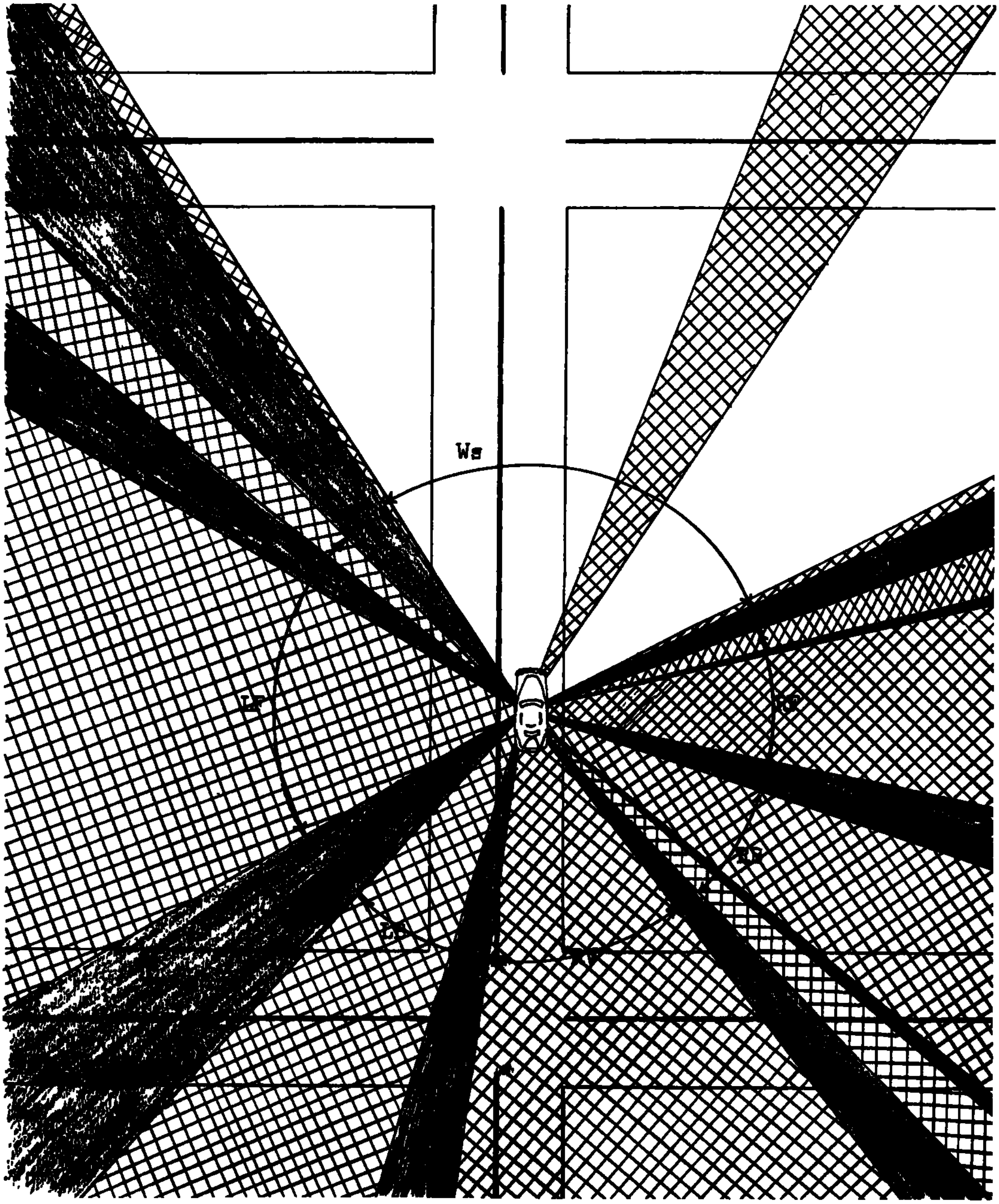

Figure 4. Automobile visibility in the horizontal plane: standard wiper pattern. Diagram illustrating angles of view cleared by standard windshield wipers on a typical passenger car (1954 Ford sedan) at the eye-level of a median-height driver, in contrast to total windshield and window angles. This is the pattern seen in Figure 5(b), produced with extra-length (12 in.), fixed-angle blades on the conventional equipment supplied with the car. Legend: Unshaded sectors—cleared by windshield wipers, shaded sectors-other window areas (not wiped), blackened sectors—blocked by permanent obstructions. Ws—windshield, RV—rear-view window, LF/RF-left/right front window and panel, LB/RB—left/right back side-window and panel.

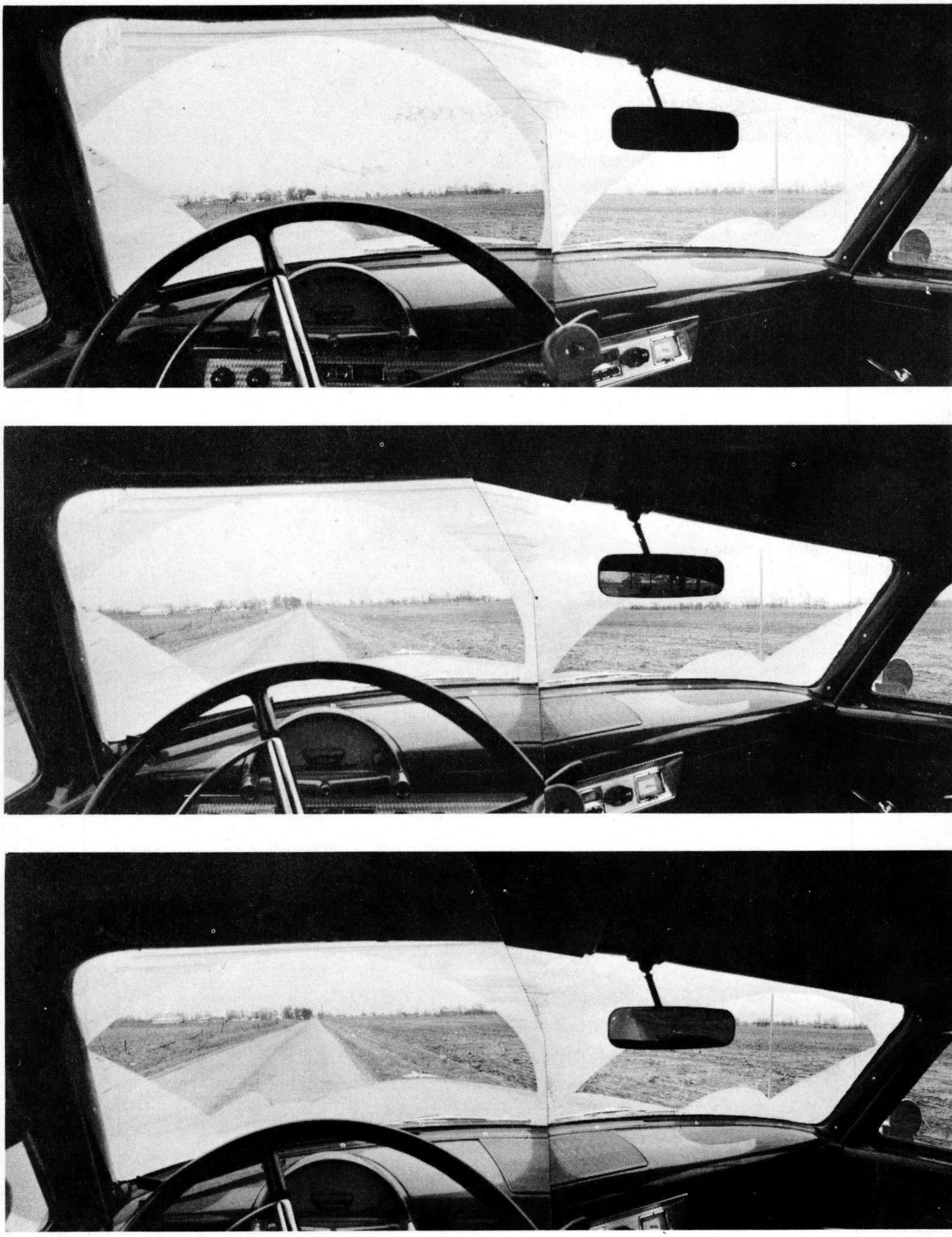

Figure 5. Standard windshield-wiper pattern on a 1954 Ford sedan, using extra-length blades (12 in.instead of 11 in.) on the conventional equipment supplied with the automobile, where the wipers point to the center when parked flush with bottom of windshield. The three pictures show the outside areas seen through the pattern as in actual operation by drivers of various heights from very short to very tall. Note the marked improvement from (a)-(b), and in (a) the vehicle on the road ahead largely concealed by the wheel.

position as seen past the corner post of your windshield? In air and sea navigation this condition is called constant bearing, and navigators know that it indicates a collision course" (4). This serves to emphasize another environmental factor in the problem of visibility and safety. Thus, whenever courses are such that an outside object continues in the same angular position (the operator's eye is taken as the reference point) while its distance grows less, a collision will follow unless action is taken to alter the situation, such as changing the speed and/or direction from the collision course. While this holds for any course and speed relationship, its converse is not necessarily true unless speeds are constant—that is, an approaching vehicle on a collision pathway will necessarily remain in the same angular position from the subject vehicle only if the speeds of both do not change. The authors have employed this special case as their

TABLE 2

FIELD ANGLES OF HUMAN VISION

Condition of Movement Permitted	Type of Field	Horizontal Limits (Temporal) Ambinocular Field (each side)	Horizontal Limits (Nasal) Binocular Field (each side)	Vertical Limits Field Angle Up	Vertical Limits Field Angle Down
(a) Head and eyes moderate movements, assumed as	Range of fixation	60°		45°	
Eyes 15 deg right or left, 15 deg up or down	Eye deviation (assumed)	15°	15°	15°	15°
	Peripheral field from point of fixation	95	(45)	46	67
Head 45 deg right or left, 30 deg up or down	Net (peripheral) field from central fixation	110	60 [c]	61	82
	Head rotation (assumed)	45	45	30 [a]	30 [a]
	Total peripheral field (from central body line)	155	105	91	112 [b]
(b) Head fixed, Eyes fixed (central)	Field of peripheral vision (central fixation)	95	60	46	67

[a] Estimated by the authors on the basis of tests on a single subject

[b] Ignoring obstruction of body (and/or knees if seated) This obstruction would probably impose maximum field of 90 deg (or less, seated) directly downward, however, this would not apply at either side, where the potentiality of seeing further downward if the body were transparent extends the total area of the visual field markedly.

[c] Maximum possible peripheral field (equal to that achieved with maximum eye deviation) This is limited by the anatomy of the structures around the eye (nose, cheeks, brows, etc.) The figures in brackets on the line preceding each occurrence of this note are calculated values, chosen to result in the maximum limit thus indicated.

All data except as noted are from Hall and Greenbaum (3).

The ambinocular field is defined here as the total area which can be seen with two eyes, but not in all parts by both at once. At the sides, it includes uniocular regions visible to the right eye but not the left, and vice versa. It is bounded only by the temporal field-limit of each eye.

The term "binocular" is here restricted to the narrower, more central region which can be seen by both eyes simultaneously (stereoscopic vision). It is bounded by the nasal field-limits of the eyes. In other words, the binocular field is the area where the individual (monoculate) fields of the eyes overlap each other, while the ambinocular field comprises in addition the marginal regions visible to only one eye.

TABLE 3

SOLID ANGLES OF HUMAN VISUAL FIELDS

		Solid Angle of Total Field: Ambinocular Angle (sterads)	Ambinocular % of 4π (= % of sphere)	Binocular Angle (sterads)	Binocular % of 4π (= % of sphere)	Unobstructed Solid Angle Seated: Ambinocular Angle (sterads)	Ambinocular % of 4π (= % of sphere)	Binocular Angle (sterads)	Binocular % of 4π (= % of sphere)
(a) Head and Eyes moderate movements	Range of fixation	2.40	19.1	2.40	19 1	2.40	19 1	2 40	19.1
(as indicated in Table 1)	Total peripheral field	9.48	75.4	7 70	61.3	8.88	70 7	7.10	56 5
(b) Head fixed, Eyes fixed (central)	Peripheral field (total)	4.38	34.9	2 97	23 6	4 30	34.2	2 89	23.0

Table 2. The solid angles intercepted by the fields of human vision, calculated from the field limits of Table 1.

The "solid angle of the total field" (as tabulated) includes any visible areas of the body (but not the head). That is, the "external" field visible beyond the body is less than this "total field" value by whatever solid angle is obstructed by the position of the body

The "unobstructed solid angle" has been corrected for the obstruction of the body when seated From the "total field" value was subtracted the solid angle intercepted (from the eye-point) by a region extending from hip to hip sideways, and from the knees to the downward limit of the vertical field (when this extends past the knees)

For a standing position, the "unobstructed" field would be intermediate between the values given

Anthropometric data from Randall et al. (7) were used to find the body angles from which the body obstruction corrections were calculated.

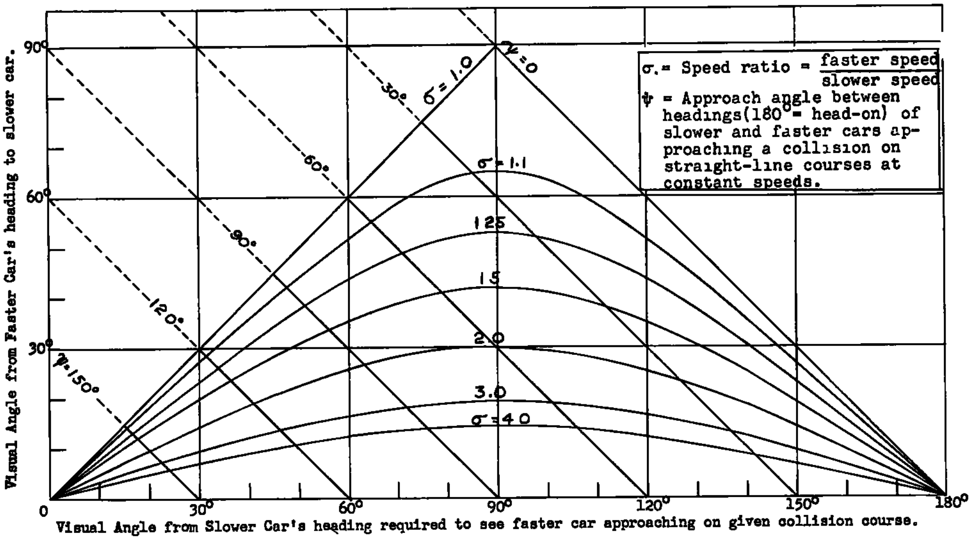

Figure 6. Collision pathways of vehicles. The graph shows the required horizontal visual angles (measured around from the forward line of motion) required by the driver of each vehicle in order to see the other when approaching on a course which will result in collision if both continue in straight lines at constant speeds. (The angle from the faster car is never over 90°.) The graph is entered with the values of approach angle and speed ratio which specify the relative (collision) courses of the two vehicles; the visual angles are then read from the axes opposite the point thus located on the chart.

initial approach to the problem and have carried out a theoretical analysis of all straight-line collision courses with constant speeds, so that the angular position of each vehicle from the other remains constant (5). The results are shown in Figure 6 which gives the values of these angular positions for surface vehicles, for various speed relationships and angles of approach between the two headings (the horizontal visual angle required from each vehicle in order that its driver can see the other approaching the collision). The faster driver never needs to see more than 90 deg to right or left, although the slower one often does; for this reason, primary attention is focused on the slower vehicle. This approach could be extended to curved courses of various types.

A driver not only must see a vehicle approaching on a collision course but also must see it in time to stop completely before reaching the pathway intersection, since only thus can he surely avoid collision—regardless of what the other vehicle does. In contrast, should he rely on merely changing speed (or direction), the other driver may inadvertently match his actions and remain on a collision course. For this reason, Figure 7 was prepared to show the distances required for each vehicle to reach a full stop after the driver decides to do so, together with the range of variation resulting from differences in reaction time prior to actual application of the brakes. This chart is based upon the data shown in the following table:

Reaction Time for Braking Range = 0 20 to 1 00 seconds, maximum normal value allowable = 0 75 seconds
Reaction Distance = Speed x reaction time
Braking Distance is that required for car to stop after brakes are put on
Stopping Distance (total) = Reaction distance + braking distance

The resulting data are

Speed (V) mph	Reaction Range ft	Distance, Max. Norm ft	Braking Distance ft	Stopping Range ft	Distance, Max Norm ft
10	3 - 15	11	5½	8½- 20	16½
20	6 - 29	22	22	28 - 51½	44
30	9 - 44	33	50	59 - 94	83
40	12 - 59	44	89	101 - 148	133
50	15 - 73	55	139	154 - 212	194
60	18 - 88	66	200	218 - 288	266
70	21 - 103	77	272	293 - 375	349
80	23 - 117	88	356	379 - 473	444

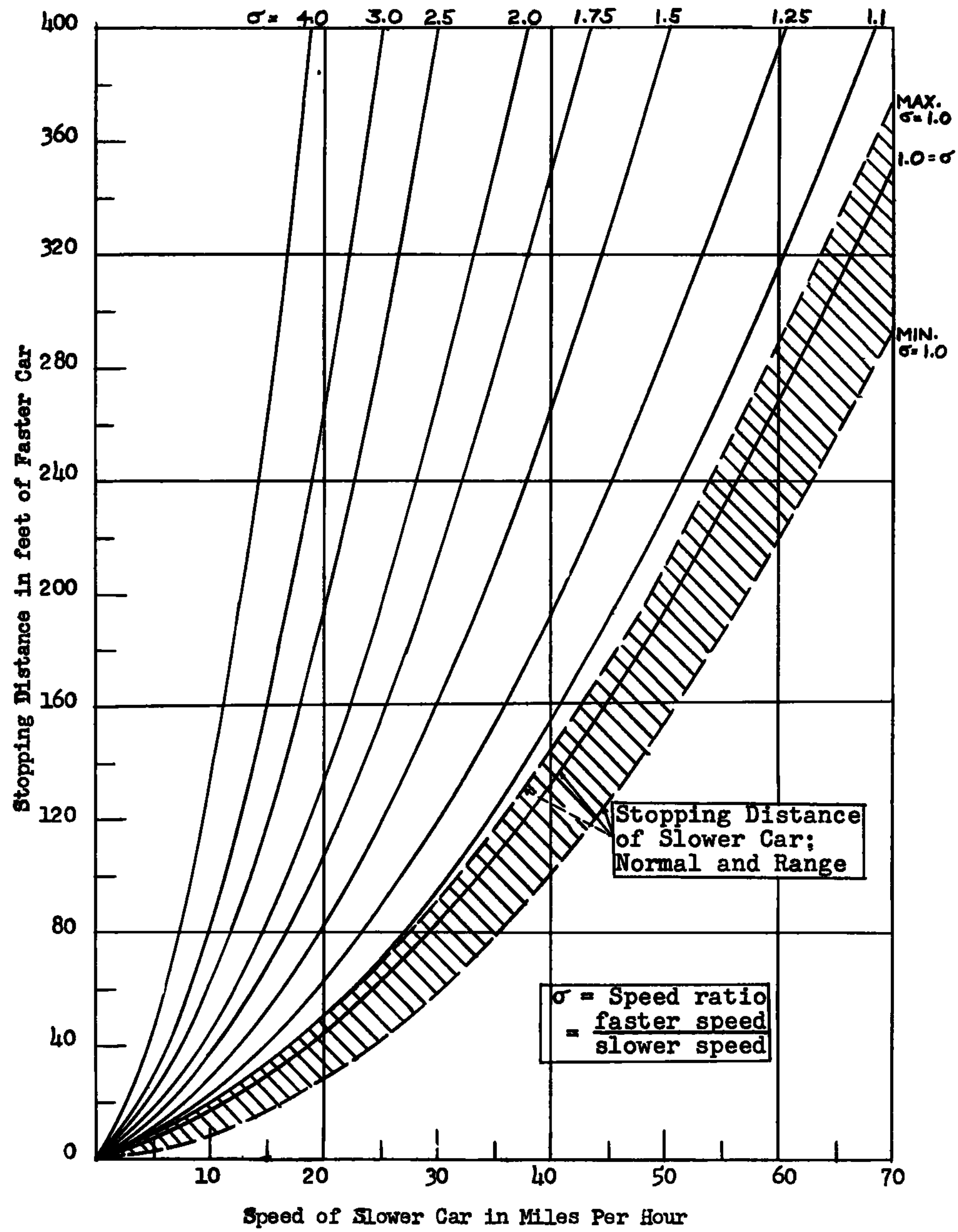

Figure 7. Stopping distance of automobiles (reaction distance plus braking distance). A dry road is assumed, with brakes and tires in good condition. The curves for speed ratio 1.0 (shaded area) give required stopping distance (at left) for a car in terms of its speed (bottom axis), including maximum and minimum values (dashed lines) for the reaction-time range from 0.20 to 1.00 seconds as well as for the greatest allowable normal time of 0.75 seconds. For the other curves, enter graph at the bottom with the slower speed and go up to the curve for the speed ratio given, across at left, read this normal stopping distance for the faster car (with the same range as the equal distance on the 1.0 curve).

The analyses can have immediate practical applications in addition to their utility for evaluating visibility provisions. The results are pertinent to the study of situations at intersections for the removal or correction of fixed visual obstructions and to the determination of local speed regulations and traffic signs. This aspect of the problem should be treated by both automobile design and highway engineers. The collision "predictor" charts may also be used in classroom instruction in driver training.

The Human Factor: Clear Seeing and Attention. "What are the necessary characteristics of a potentially hazardous object in order for it to constitute an adequate visual stimulus?" Consideration of some limiting factors in man's visual equipment is involved. The human eye is a most remarkable and sensitive instrument with the ability to distinguish separations of lines subtending a visual angle of 1 minute or less. It may function with some degree of effectiveness over a range of stimulus energy of about ten billion to one. It may also detect flicker in frequencies of 50 to 60 cycles per second if the light intensities are sufficiently high. There are, however, definite limitations to seeing. Fundamental variables which must be above certain limiting values if an object is to be recognized are as follows:

1. The visual size, or the visual angle subtended by the object or some critical detail of it. This is generally expressed in minutes of (visual) arc, because an object decreases in visual size with increasing distance. Under optimal conditions, a visual size subtending an angle of one minute or less can be distinguished.
2. The contrast between the object and its background (the ratio of the difference in the brightness of the object to the brightness of the background). This is expressed as percent brightness contrast.
3. The level to which the object is illuminated (its absolute, or photometric, brightness).
4. The time the retina is exposed to the image of the object.

Luckiesh and Moss (6) show the relationship of visual angle, contrast percent and background brightness for various combinations of these factors which result in "clear seeing" and "no seeing."

The contrast and object brightness are two factors which can be influenced for safety by selection of color, characteristics of the surfaces, or use of an additional energy source, such as lights. At some future time, there may be installed an automatic "forward" anti-collision light which will remain on at all times when the car is moving forward. A significant number of drivers now utilize this means of increasing visibility to oncoming cars by manual operation of headlights during daylight hours when passing on the highway at moderate or high speeds.

The driver can and must make a contribution to the visual aspects of safety. He should know generally the limitations imposed on normal human visual capabilities; in the event he suffers from a visual defect, he should be acutely aware of the effects of this additional restriction. This invites the attention of not only the design engineers, but also those who can apply measures to influence man—by traffic control, disciplinary measures, driver medical examination and driver education.

As for the other aspects of the visual problems in safety (those having to do with the vehicular operator looking elsewhere) and adequate visual images which fail to register, the responsibility is almost if not entirely that of the psychologist, the physiologist, the biophysicist and the biochemist. There is little the engineer can do except provide technical consultation to assist in the biological research and, perhaps, advise, on the basis of experience in traffic control problems, as to the value of disciplinary action in specific traffic situations.

What can the biologist do? Working with the engineer, he can provide detailed descriptions of man's visual capabilities and specify human requirements in the driving situation which should be met by the automotive and the highway designer. Working with those engaged in driver training, he can provide information on the inter-relation of the four important variables in vision as a basis for a continuous development and improvement in driving methods and practices. Working with the driver, the physician and the research biologist must determine physical (including mental) fitness and must instruct man in at least the elements of the physiology of vision. For example, a driver should know the time required for the eye to accommodate to see a near object after looking at a distant object, or the greater time to shift his focus from a near to a far distance; the limits of his ability to judge the relative position of two cars or other objects at a distance; and the influence of twilight, glare, fatigue and age on vision.

So much for what the biologist can do by working with others. The biologist's most important responsibility in vehicular safety, which is his alone, is that of studying the problem of attention. How can a driver be kept looking about and paying attention, so that an image of the potentially hazardous object will fall on the retina and will be perceived and appropriate action initiated?

There are at least five major factors which may be considered briefly in connection with attention (7). These, and many others, must be the subject of intensive research investigation if a sufficient knowledge of the mechanisms involved to prevent accidents due to lapses of attention is to be attained.

1. Free and Controlled Attention. In free attention there is the question of which of a number of objects will "catch the eye" and elicit a response. In controlled attention there is a specific response to a set of stimuli alike in nature. While potentially hazardous objects may be sufficiently "alike in nature" to insure that controlled attention benefits safety, can the role of free attention in avoiding accidents be evaluated?

2. Shifting and Fluctuating Attention. While an object or group of objects may receive an individual's attention for a period, his attention is likely to fluctuate in degree or to shift from one object to another. To what degree is safety dependent upon time factors for "seeing" and for shifting the gaze, and to what degree on the probability of bringing the hazardous object into view through shifting and fluctuation?

3. Distraction. An involuntary interruption of controlled attention or a shifting of it is implied. A priori, it might be considered as prejudicing safety, but this is not necessarily so; too great a pre-occupation with the highway without breaks in the monotony of the environment has been considered as conducive to accidents.

4. Divided Attention. This implies a voluntary attempt to do two things at once; it would appear to be one variety of controlled attention, where conscious direction is applied alternately to the several tasks. Quite possibly the psychologists would not agree with this concept, but it would seem that this divided attention may involve motor acts, such as movement of the limbs which are initiated voluntarily but controlled to some extent by the peripheral nerve-muscle mechanisms, or sensory perception and interpretation, such as alternately judging the cars forward and in the rear view mirror in attempting to avoid a "chain reaction" smashup.

5. Span of Attention. This involves the ability to remember or take account of all objects presented at a glance and make an effective response. This is a spatial rather than a temporal phenomenon.

Accidents are determined by the interaction of the man, the machine, and the environment. Success in accident prevention depends on the engineers and the biological scientists working together to discharge the responsibilities of their respective fields.

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Effect of Rest Pauses and Refreshment on Driving Efficiency*

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● REST pauses have been effectively utilized in certain industries to combat the loss in worker efficiency due to fatigue and monotony. Although there is not complete agreement as to the optimum length of time for the pause or when it should be introduced in the work period (8), few will deny its practicality.

Early research (6) has shown that long automobile drives tend to produce a loss of efficiency of certain discriminations, association processes, and motor reactions similar to those required in driving. These observations also suggest that a long automobile drive may render a driver temporarily susceptible to accidents. Much has been attributed to highway hypnosis with very few experimental facts available. One study by Lauer and McMonagle (5) touched on certain aspects of the problem.

Reports by certain insurance companies operating throughout the country indicate that a large percentage of their accidents occur during the first 3 hours of driving. Their insured are for the most part commercial drivers who start on a trip and drive for several hours. For lay drivers this would not be very convincing since it is conceivable that most of their trips are completed within a period of 3 hours.

It seemed advisable to set up an experimental situation to determine what effect, if any, the introduction of a rest pause with refreshments at regular intervals would have on the efficiency of automobile drivers.

This is the first phase of a special study on the effect of refreshment pauses on driving efficiency and will cover only the orientation and practice period of approximately 6-hour duration. Three hours were spent behind the wheel in a simulated driving situation. The remainder of the time was spent in orienting and testing the subjects on a battery of efficiency tests.

METHOD AND PROCEDURE

The method was that of a controlled experimental approach using matched groups to determine the nature of their performance in a simulated driving situation continuing for a 3-hour period. While it was impossible to match the groups exactly, they were matched as nearly as possible with respect to sex, age, and driving experience.

Thus two groups of 28 and 25 subjects respectively, used in the practice run, are included and the results from their performance will be considered in terms of (a) nature of their efficiency curves on several aspects of simulated driving as described, and (b) basic efficiency measurements made before and after the 3-hour driving period.

These two sets of measurements were made in order to determine, if possible, what psychological or physiological effects might result from a period of 3 hours performance with and without pauses such as are described.

One group of 28 subjects, used as a control, drove for three hours straight, receiving no rest pause or refreshments. Henceforth they will be designated as the no-pause group. The other 25 subjects, making up the experimental group, were served tea just prior to the driving period. After $1\frac{1}{2}$ hours of continuous driving each was given a 15-minute rest period during which time tea was again served. The drivers following this procedure will be referred to as the refreshment-pause group.

FACTORS CONSIDERED

The experimental procedure consisted of administering a series of efficiency tests to each driver before and after the simulated driving phase of the study. Included a-

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mong the tests were the following:

1. The Steadiness Test. The subject moves a stylus downward through a gradually narrowing slot between two metal strips. The distance that the subject moves the stylus downward without touching the sides determined his score for that trial. A series of ten trials, alternating hands each trial, constituted the test. The average score is used as the index of steadiness of muscle control or lack of tremor.

2. Choice Reaction Time. The subject is seated with the right foot placed on a break-type switch adjacent to a simulated brake pedal. He is instructed to hold his right foot on the switch just as though he were pressing the accelerator of an automobile.

Green, amber, and red stimulus lights are presented in random order. The subject is instructed to respond only to the red light, that is, as soon as the red light appears, to move his right foot from the switch and place it on the brake pedal as quickly as possible.

Reaction time to the red light is recorded. False reactions, such as responding to a green light, are counted by an electronic device. The test continues until the red light is presented 25 times. Several amber and green lights are given as distraction stimuli. The number of presentations is constant for each subject.

3. Coordination. This is measured with a device developed at the Driving Research Laboratory for use with Army drivers. A platform maze is controlled by means of two levers. One moves the tilting top upward or downward from front to back. The other tilts it in a similar manner from side to side. A steel ball bearing of 7/8-in. diameter can be guided around the maze by manipulating the levers. At various places along the courses, holes are located through which the ball will drop if the levers are not manipulated properly to maneuver the ball around them. The object is to guide the ball bearing through the maze without its falling into one of the holes. There are 20 holes numbered 5, 10, 15, 20, etc., up to the end dock which is 100.

The holes are numbered progressively so that the further the ball has advanced around the maze before it falls through a hole, the higher the score. Thus the number at the hole where the ball is lost determines the score for the trial. Each subject is given five trials and the average is used as a score. It is postulated that this device measures motor control, carefulness and perseverence, along with perceptual accuracy and attention.

4. Blood Pressure. The Tycos Self-Recording Sphygmomanometer was used for measuring blood pressure. This instrument is particularly adapted for use in this type of study since it makes a graphic recording that can be studied by more than one person and increases objectivity in the analysis of results.

5. Galvanic Skin Response, Pulse, and Respiration. A Stoelting No. 22496 Deceptograph was used for obtaining these measurements. The subject is seated

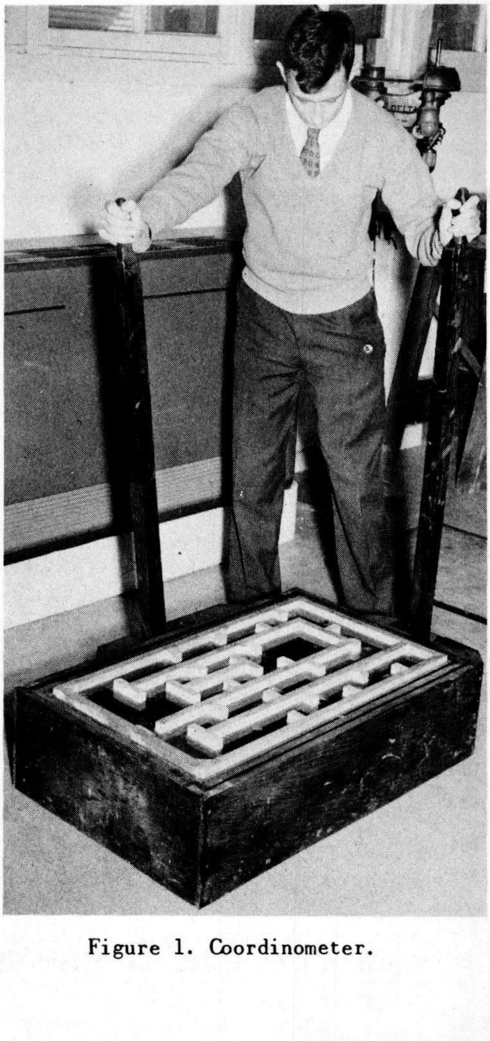

Figure 1. Coordinometer.

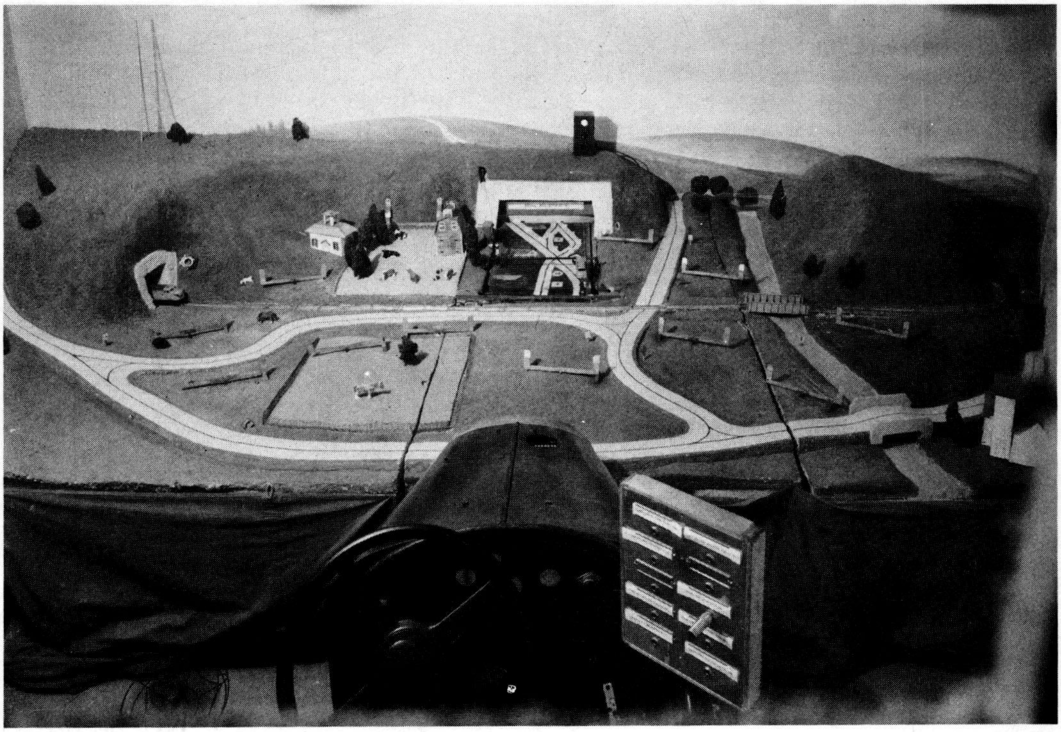

Figure 2. Drivometer.

comfortably in a lounging chair and told to relax as much as possible. A pneumatic cuff is placed around one wrist and inflated sufficiently to bring out the pulse beat.

The pneumograph, a black rubber convoluted tubing with suitable attachments, is fastened around the chest tight enough so as to stretch and contract as the subject breathes. A finger electrode is attached to the middle finger of each hand in order to obtain a measurement of skin resistance. A record of the pulse, respiration and galvanic skin responses is thus obtained for a one-minute period for each measurement—both before and after the driving period.

After the preliminary efficiency tests, each subject in the refreshment-pause group was taken into a booth built to resemble a small roadside stand where tea was served, with or without additives as desired. The subject was allowed to drink the tea at his leisure, second servings were available, if desired. The no-pause group went directly from the efficiency tests to the simulated driving phase of the study.

The driving performance was done in the laboratory. The apparatus used was the Drivometer (3, 4, 5) located in a special booth designed at Iowa State College for measuring and recording the reactions of drivers under laboratory conditions. The Drivometer is a device so constructed that the subject sits in a mock-up car using full-size automobile controls to drive a miniature car around a traveling roadway.

The special booth built around the Drivometer is designed to provide proper controls of the simulated driving conditions. The booth is air conditioned and the temperature kept at 70 deg. The relative humidity averages around 57 percent.

In order to compute a steering score, vertical protrusions are attached to the right side of the roadway in such a fashion that when the miniature car crosses one, it operates a quick-acting counter. The total number of contacts made constitutes the steering score. Thus the degree to which one keeps the car on the road is objectively recorded.

A signal box containing a red and green light similar to the conventional traffic control devices is placed above and to the right of the traveling roadway. The time required for the subject to depress the brake pedal after a red light appears in the signal box is described as stop-light-response time.

An electric train is installed in the special booth on the mock-up landscape so that it can be made to emerge from a tunnel into the view of the driver at the will of the experimenter. The driver is instructed to depress the brake as soon as he sees the train.

As the train leaves the tunnel an electric contact starts a Standard time clock calibrated in terms of $\frac{1}{100}$ second which is stopped when the brake pedal is first depressed. The time elapsing has been designated in this study as train-reaction time.

Located above the roadway is a small aperture through which printed instructions are presented. To the right of the driver is a control box on which is printed another set of each of the instructions which appear in the aperture. The subject is instructed to stop the car as soon as he sees instructions appear in the aperture and plug in a jack below the matching instructions on the control box. Then he follows the directions as stated. The time required for the subject to note and read the instruction line, comprehend it, and plug in as instructed constitutes the error time.

At the beginning of the driving phase, a control test run covering the series of seven instructions is made. During this time the red light and the train are each presented on five different occasions. The time required for the driver to perform the exercises as outlined in the instructions is measured by a second Standard time clock and recorded as the total-trip time. This series of evaluations will be referred to as a test-run. The before and after test-runs yielded the following data: (1) steering score, (2) stop-light-response time, (3) train-reaction time, (4) error time, and (5) total-trip time.

THE WORK PERIODS

The subjects were told to drive the Drivometer just as they would on the open highway as soon as the instructions ceased to appear in the aperture at the end of the test-run. The stop-light and train are consistently presented five times each ½ hour. These ½-hour intervals of simulated driving are called work periods.

After 1½ hours of continuous driving, the subjects in the refreshment-pause group are given a 15-min rest period and again served tea as previously described. The no-pause group drive for 3 hours straight.

Ten minutes prior to the end of the last work period, a second test-run is given. As soon as the simulated driving phase is completed, the efficiency tests are administered again in the same sequence as followed before, thus completing the experimental cycle in this, the first phase of the study. The subjects are paid standard wages by the hour for the time taken by the experiment—about 6 hours for the practice run.

TREATMENT OF RESULTS

The mean scores on the factors measured during the test-run and also the mean scores on the factors measured by the efficiency tests were computed for the two groups,

TABLE 1

TEST-RUN - REFRESHMENT-PAUSE GROUP
(Made to establish the presence of practice effects and/or decrement)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Total-trip time	4.716	4.212	.504 A[b]	1.115
Error time	1.153	.838	.315 A	2.067[a]
Stop-light-response time—mean	2.122	2.145	-.023 B	.032
Stop-light-response time—a. v.	2.060	2.632	-.572 B	.401
Steering	99.760	103.800	-4.040 A	.348
Train-reaction time—mean	.924	.936	-.012 B	.063
Train-reaction time—a. v.	.788	.640	.148 A	.851

[a] Significant at the five percent level.
[b] A = increment or improvement, B = decrement or loss.

both before and after the driving period. The differences between the before and after group mean scores were computed for each variable measured for both the refreshment-pause and the no-pause group. A t-test with pooled variance was made to determine whether the differences found were statistically significant.

No attempt was made to determine the significance of group differences in this phase

TABLE 2

TEST-RUN - NO-PAUSE GROUP
(Made to establish the presence of practice effects and/or decrement)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Total-trip time	4.726	4.207	.519 A [c]	1.312
Error time	1.081	.878	.203 A	1.436
Stop-light-response time—mean	3.128	1.319	1.809 A	2.131 [a]
Stop-light-response time—a. v.	3.938	.706	3.232 A	2.763 [b]
Steering	83.214	87.036	-3.822 A	.420
Train-reaction time—mean	1.139	1.024	.115 A	.699
Train-reaction time—a. v.	.820	.619	.201 A	1.021

[a] Significant at the five percent level.
[b] Significant at the one percent level.
[c] A = increment or improvement, B = decrement or loss.

TABLE 3

EFFICIENCY TESTS - REFRESHMENT-PAUSE GROUP
(Before and after practice run)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Blood pressure				
Systolic	127.360	125.280	2.080 A [c]	.263
Diastolic	66.120	66.800	-.680 B	.324
Steadiness	8.128	8.820	-.692 A	1.144
Choice reaction time				
False attempts	2.560	2.040	.520 A	.524
Mean	38.297	37.670	.627 A	.358
A. V.	7.313	6.262	1.051 A	1.731
Coordination	43.400	46.280	-2.880 A	.356
Pulse				
Rate	78.160	70.920	7.240 B	2.865 [b]
Regularity	1.007	1.015	-.008 B	.707
Oscillation	1.200	1.120	.080 B	.395
Bridge measurement	102150.400	99016.800	3133.600 B	.063
Respiration				
Frequency	15.120	15.240	-.120 B	.084
I/E ratio	.767	.733	.034 B	.412
I/E variability	.287	.157	.130 A	2.029 [a]

[a] Significant at the five percent level.
[b] Significant at the one percent level.
[c] A = increment or improvement, B = decrement or loss.

TABLE 4

EFFICIENCY TESTS - NO-PAUSE GROUP
(Before and after practice run)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Blood pressure				
Systolic	132. 000	120. 071	11. 929 A[b]	1. 835
Diastolic	67. 893	66. 143	1. 750 A	. 764
Steadiness	8. 028	7. 982	. 046 B	. 110
Choice reaction time				
False attempts	1. 678	. 786	. 892 A	2. 730[a]
Mean	38. 840	39. 924	-1. 084 B	. 675
A. V.	7. 876	7. 417	. 459 A	. 534
Coordination	43. 464	46. 750	-3. 286 A	. 427
Pulse				
Rate	75. 750	71. 178	4. 572 B	1. 786
Regularity	1. 002	1. 006	-. 004 B	. 100
Oscillation	. 928	. 964	-. 036 A	. 161
Bridge measurement	101580. 357	112371. 071	-10790. 714 A	. 089
Respiration				
Frequency	15. 178	15. 214	-. 036 B	. 031
I/E ratio	. 775	. 772	. 003 B	. 071
I/E variability	. 335	. 401	-. 066 B	. 584

[a] Significant at the one percent level.
[b] A = increment or improvement, B = decrement or loss.

of the study. They are being considered in the main experimental run during which each subject spent six hours behind the wheel. The objective in this phase of the study was to determine the nature and extent of practice effects and/or decrements on the various measures used.

The factors measured during the work periods were analyzed graphically so that not only the differences but also any changes in direction of performance could be revealed.

The mean scores, differences between the means, the t-values for the factors measured during the test run are shown in Table 1 for the refreshment-pause group and in Table 2 for the no-pause group.

The error time was significantly less on the second test run for the refreshment-pause group. Since this was the first time any of the subjects had driven the Drivometer, it is probably due to practice effect and learning rather than to an increase in efficiency. The purpose of this phase of the study was to practice all subjects.

The significantly faster stop-light-response time on the second test-run for the no-pause group as compared to the very low t-value indicating no change for the refreshment-pause group seems to substantiate previous findings (7) suggestive of a calming effect from the ingestion of tea. This may be an indication that tea has a beneficial effect on driving performance. The National Safety Council has cited data indicating that reaction time is related to accident rate with the quick reactors having the higher rate.

The highly significant decrease in choice-reaction time false attempts by the no-pause group is contrary to previous findings and against expectations. No satisfactory explanation can be offered for this observation.

The highly significant decrease in pulse rate as well as the significant decrease in breathing variability by the refreshment-pause group seems to indicate a lower level of tension which would possibly have a favorable effect on driving by lessening fatigue.

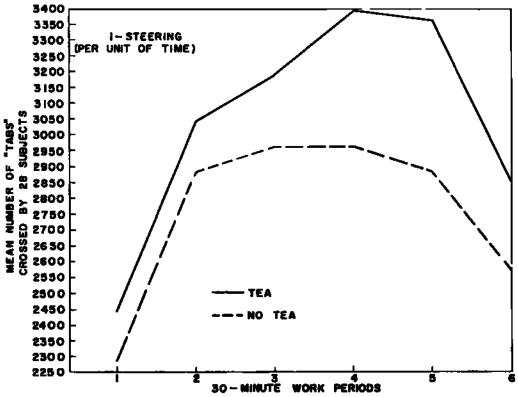

Figure 3. Steering (per unit of time).

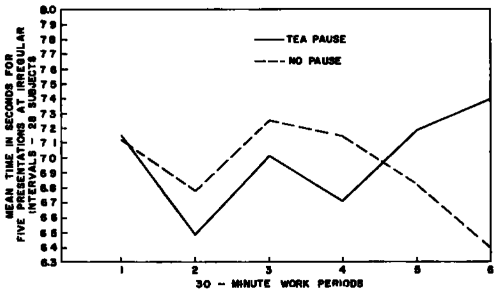

Figure 4. Train reaction time (mean).

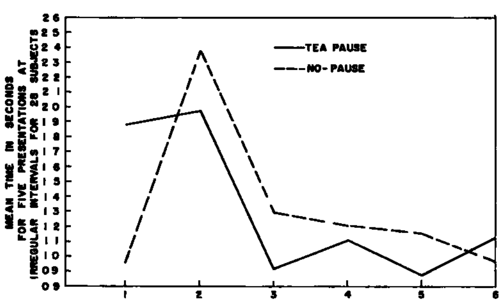

Figure 6. Stop light response time (mean).

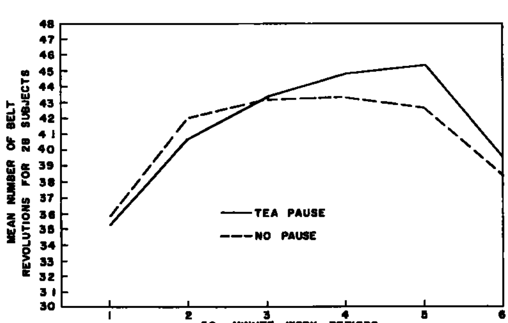

Figure 8. Belt revolutions (per unit of time).

The results recorded for the factors considered during the work period are presented graphically.

The graphs indicate the trend of the work curves throughout the 3-hour period. The tabulations were made at 30-min intervals hence the graph shows a progressive account of performance. Appropriate methods of evaluation of these trends are being considered, both parametric and nonparametric (1).

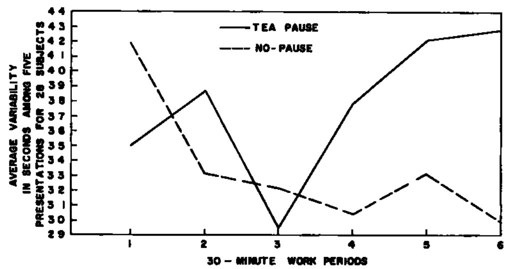

Figure 5. Train reaction time (a.v.).

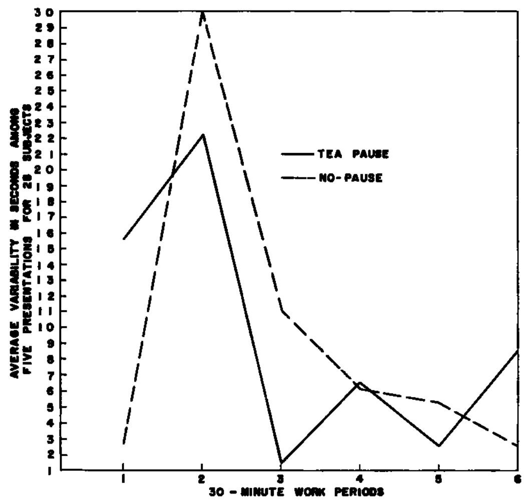

Figure 7. Stop light response time (a.v.).

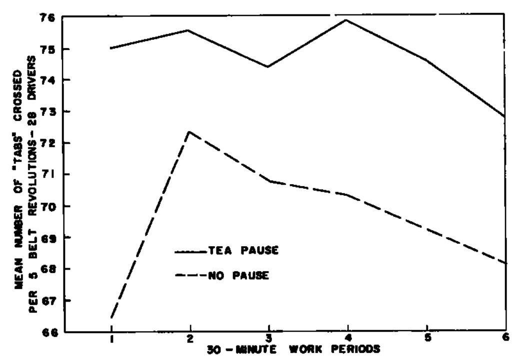

Figure 9. Steering efficiency (per 5 revolutions).

SUMMARY AND CONCLUSIONS

Two groups of 28 and 25 subjects, respectively, were given a practice run of three hours simulated driving on the Drivometer which was installed in a special air-conditioned booth. A series of efficiency tests were administered both before and after the simulated driving period.

One group of drivers, the refreshment-pause group, was served tea just before the driving phase of the study and again during a 15-min rest period after 1½ hours performance. The other group received no rest pause or refreshments. Data were recorded on both groups every ½ hour during the simulated driving period for the factors that could be subjected to continuous evaluation.

The variables that lent themselves to statistical evaluation were so analyzed. The other factors were analyzed graphically to determine the nature, extent, and direction of trends in performance.

A point regarding significance should be mentioned. Without a large number of cases, small differences which are found between two sets of means may not show significance by use of the t-test or comparable tests of significance. When curves consistently indicate a small difference at a number of different points, ordinary two-group comparison methods do not seem to apply. Further study is being made of evaluation methods suitable to the data.

In interpreting the results it must be remembered that the data were gathered during the orientation and practice period preliminary to the main experimental run which involved two groups of 28 subjects each taken through a 9-hour experiment. This study will be reported later. However, the findings seem to support the tentative conclusion that the general effect of the tea and the pause combined has a quieting effect which is reflected in (a) the tendency to work a little harder, (b) sustained alertness, and (c) greater efficiency at the problem at hand. From several phases of the study there is some evidence of a quieting effect and reduction of tension for the refreshment-pause group. Further interpretations are being withheld pending the completion of analysis of the experimental run.

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Analysis of "Near Accident" Reports

COMMITTEE ON ROAD USER CHARACTERISTICS, T. W. Forbes, Chairman[1]

This was a pilot study to investigate information on driver behavior and other factors as causes of accidents obtainable from reports of accidents that almost happened ("near accidents"). Such reports have the advantage that drivers who were almost involved can describe what happened without fear of legal consequences. They may also be less disturbed by emotional factors known to interfere with accurate reporting of actual accidents.

A total of 179 "near accident" reports were obtained from 400 sets of report forms distributed. Reports were largely from people interested or working with traffic. The "other" drivers included, however, should represent a more random sample of drivers. The sample of "near accidents" and drivers, therefore, is not necessarily a representative cross-section. Also their dramatic quality may result in certain "near accidents" being remembered and reported in preference to other less dramatic ones.

However, the study does indicate what can be achieved by this method of research. It does allow indication by the drivers of important factors of the situation at the time. This makes possible selection of important combinations of factors and elimination of much irrelevant (and therefore confusing) material often automatically included in large samples of accident report data.

The results indicate the importance of numerous combinations of human and physical factors, 2 to 7 or more factors being of importance in most of the "near accidents." Only 2 of the 179 were attributed to a single factor and even these might include other factors. Speeds ranged from stopped to 65 mph and, in many cases were not indicated to have been of major importance. "Hurry," however, occurred with both lower and higher speeds and occurred in a larger proportion of "near accidents" than would be expected by chance.

Thus the study shows why the search for single accident causes has not been generally successful in uncovering fundamental causes of accidents. The number or relative proportion of specific causal factors reported is not necessarily representative. Rather the variety and types of factor combinations are of importance as is the illustration that the method can be used fruitfully.

● ALTHOUGH entirely too large from any other point of view, the number of traffic accidents in any practical period of time has been too small to allow reliable analysis of accident causes from accident records. Furthermore, certain information has been difficult to obtain from those involved in actual accidents due to fear of legal complications.

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[1] The members of the Committee circulated report forms to drivers in various parts of the country and it is a pleasure to acknowledge their contribution and that of those who filled out and submitted reports.

The initial stages of the analyses were made possible through clerical assistance contributed by the National Research Council "Council-wide" Committee on Highway Safety Research when the chairman was its Technical Director. Clerical and secretarial assistance and time of the chairman for drafting of the report were made available by the American Institute for Research, Pittsburgh, since he joined its staff.

The chairman carried out or supervised and is, therefore, responsible for the analysis, conclusions and interpretations, which do not necessarily represent those of individual committee members of National Research Council Organizations, nor of the American Institute for Research. The report, however, has been reviewed by the Committee and suggestions have been incorporated. Publication was recommended to suggest and stimulate further research along such lines.

TABLE 1

AGE OF REPORTING DRIVERS

Age	Private Drivers		Commercial Drivers	Total Drivers
	Men	Women		
15-19	1	0	0	1
20-24	4	2	0	6
25-29	3	1	7	11
30-34	9	2	6	17
35-39	13	1	9	23
40-44	2	0	6	8
45-49	8	1	3	12
50-54	11	0	0	11
55-59	5	0	7	12
60-64	1	0	0	1
65 and up	1	0	0	1
Unknown	15	1	3	19
Totals	73	8	41	122

A study of "near accidents" on the other hand does not meet with these difficulties since there are many more such occurrences and since drivers who have avoided accidents have no motivation for withholding information.

On the basis of successful studies of aircraft "near accidents," it was suggested[2] that the committee might well initiate such a study of traffic accidents to investigate what information could be obtained on accident causes by this method. Accordingly, at its January 1952 meeting, such a study was authorized. Report forms were circulated by members of the committee a month or so later and (in order to increase the number of returns) a second set of forms was circulated by the members as directed by the committee after its January 1953 meeting.

METHOD

For the description of each "near accident," a report form (see Appendix) was drawn up which called for (a) a brief description of what happened (b) the reporter's opinion as to factors of most importance and (c) check list items on "hurry," attention, and month, season and day of the accident. In addition, a letter giving the purpose of the study and requesting cooperation included name, age, occupation, driving experience, city and state. The latter items were for determining the characteristics of the reporting sample and it was indicated that they would be considered confidential. A sample form was filled out describing a "near accident" occurrence and packets of five forms, a sample form and the letter of instructions were clipped together for distribution to each person.

With each packet of report forms was included a stamped envelope addressed to the chairman of the committee. It was requested that all forms be sent to him direct so that there would be no influence on reports from any possible fear that friends and colleagues would see them before they were sent in.

The twenty committee members each undertook to distribute forms to ten individual drivers who had sufficient interest and objectivity to report reliably. Each committee member distributed five additional sets of forms the second year. In addition, forms were distributed to a group of bus drivers and commercial fleet supervisors by certain members of the committee.

A total of 179 reports of "near accident" occurrences were received from a total of 122 drivers out of the total of approximately 400 sets of forms distributed. The number of reports from each individual were for the most part one or two with a few contributing three or four.

CHARACTERISTICS OF THE REPORTING SAMPLE

The individuals who sent in reports constituted, of course, a highly selected sample which cannot be considered a cross-section of the driving population as a whole.

TABLE 2

DRIVING EXPERIENCE OF REPORTING DRIVERS

Years	Private Drivers		Commercial Drivers	Total Drivers
	Men	Women		
0-3	1	1	0	2
4-7	0	1	4	5
8-11	3	2	4	9
12-15	6	0	3	9
16-19	6	2	0	8
20-23	5	0	2	7
24-27	2	0	2	4
28-31	10	0	2	12
32-35	7	0	4	11
36-41	3	1	1	5
Unknown	21	1	4	26
Totals	64	8	26	98

Miles Thousands	Private Drivers		Commercial Drivers	Total Drivers
	Men	Women		
25-99	4	0	0	4
100-199	2	0	3	5
200-399	1	0	5	6
400-599	1	0	2	3
600 and over	1	0	5	6
Totals	9	0	15	24

[2] Through the National Research Council "Council-wide" Committee on Highway Safety Research from the experience of scientists in the field of aviation psychology.

TABLE 3

OCCUPATIONS OF REPORTING DRIVERS

Occupations	Private Drivers		Commercial Drivers
	Men	Women	
Bus operator	0	0	20
Fleet supervisor, garage manager, etc.	0	0	6
Safety manager, supervisor, etc.	0	0	8
Accounting and clerical	3	4	0
Engineering including traffic and transportation	19	0	0
Education and administration	13	1	1
Research and administration	12	1	0
Industrial Administration and personnel	1	0	3
Editorial	0	1	0
Business and insurance	3	0	0
Unknown	22	1	3
Totals	73	8	41

TABLE 4

VEHICLES INVOLVED

Vehicles Involved	Private Drivers	Commercial Drivers	Total
Truck	1	1	2
Bus	0	3	3
Auto	106	16	122
Truck and auto	22	2	24
Bus and auto	2	21	23
Truck, bus, train and auto (various combinations)	1	7	8
Totals	132	50	182

TABLE 5

NUMBER OF VEHICLES

Total Vehicles	Private Drivers	Commercial Drivers	Total
One	16	5	21
Two	62	30	92
Three	25	9	34
Four	4	3	7
Five and over	2	0	2
"Several"	8	2	10
Line of traffic	9	1	10
Totals	126	50	176

The results of the study, therefore, are suggestive only. However, it should be pointed out that many of the reported occurrences involved a like number of other drivers, who should be a more random group.

Tables 1 and 2 show that the ages of those reporting ranged from below 20 to over 65 years and that their driving experience ranged from 2 to over 40 years. Some of the commercial drivers reported experience in hundred thousands of miles.

Occupations of the reporting drivers were for the most part clerical, semi-professional and professional. The commercial vehicle operaters and transportation fleet supervisors were mentioned above (see Table 3).

CHARACTERISTICS OF THE "NEAR ACCIDENT" OCCURRENCES

Certain physical characteristics reported throw some light on the sample of incidents obtained. Taken as a whole, these indicate a wide range of variables such as location, type of maneuver included, type vehicles involved, range of speeds and times of day and season of the year.

"Near accidents" involving passenger cars only, constituted by far the largest proportion of reports with combinations of truck and auto (including semi-trailer) and truck and bus the next largest. By far the largest number of reports involved two vehicles with three vehicles and single vehicle being next most frequent in that order (see Tables 4 and 5).

Speeds of the reporting driver's vehicles ranged from "stopped" to 65 to 70 mph with the occurrences pretty well spaced over the speed range as shown in Table 6. There was some peaking at the 50 to 55 mile speed for private driver reports which probably reflected the usual cruising speed of passenger cars in many states. In about one third of the reports, speed was not stated since it did not play a major part in the occurrence. In the remainder "high speed" or "too fast" were mentioned in a total of 18 cases only. This is of considerable interest since it means that in the descriptions, excessive speed or a speed "too fast" for conditions was reported as a cause in only about 10 percent of the reports.

Visibility conditions were good for the majority of the "near accidents" reported (see Table 7) and types of maneuvers involved were distributed among stopping, passing, turning and wide range of others (Table 8).

Table 9 shows the incidents to have been about equally located in urban and rural territory and to have been more frequent at intersections than on curves and hills. The remaining 80 incidents with location unstated would be assumed to be between intersections on streets or highways.

TABLE 6

REPORTED SPEEDS

Driver's Car Speed	Private Drivers	Commercial Drivers	Total Reports
0-slow, stopping, starting	18	17	35
5-9	2	0	2
10-14	0	1	1
15-19	3	5	8
20-24	4	2	6
25-29	4	1	5
30-34	6	1	7
35-39	4	0	4
40-44	8	2	10
45-49	6	0	6
50-54	18	1	19
55-59	9	1	10
60-64	4	1	5
65-69	3	0	3
Unknown	35	11	46
"Too fast"	2	0	2
"Normal"	5	0	5
Totals	131	43	174

TABLE 7

VISIBILITY

Visibility Condition	Reported by		
	Private Drivers	Commercial Drivers	Total Reports
Twilight	10	2	12
Blind corner	12	1	13
Glare	5	1	6
Poor lighting	1	0	1
Rain	10	3	13
Fog	2	1	3
Snowing	1	0	1
Poor visibility	8	4	12
Good visibility	72	29	101
Totals	121	41	162

TABLE 8

TYPE OF MANEUVER

Type of Maneuver	Reported by		
	Private Drivers	Commercial Drivers	Total Reports
Backing	1	1	2
Stopping	19	8	27
Passing	33	12	45
Turning	29	15	44
Other (entering road, straight rear-end collision, off road, etc.)	66	22	88
Totals	148	58	206

DRIVER'S OPINIONS AS TO CAUSES

The driver's opinions on factors of causal importance from Section B of the report blank were analyzed. Of the total 179 reports, 157 thought either self or other drivers to have been at fault. In about one third of the 157, the drivers reported themselves at fault either alone or together with another driver. Other dri-

TABLE 9

LOCATION

Location	Private Drivers	Commercial Drivers	Total Reports
Urban	32	30	62
Rural	64	15	79
Total	96	45	141
At intersection	40	23	63
Curve	17	3	20
Hill	15	1	16
Totals	72	27	99

TABLE 10

DRIVER'S OPINIONS ON CAUSAL FACTORS

Driver's Opinion as to Cause	Private Drivers	Commercial Drivers	Total Reports
At fault			
Self	39	14	53
Others	72	32	104
Totals	111	46	157
Poor visibility	9	0	9
"Hurry" as cause	5	6	11
Misjudgment			
Speed	6	2	8
Other's intent	8	2	10
Other	9	1	10
Inattention	27	17	44
Speed	31	9	40
No signal	14	3	17
Unexpected maneuver	20	3	23
Totals	129	43	172

vers were held to be at fault in 104 cases (Table 10).

This table also summarizes opinions as to factors of importance as causes. Poor visibility, hurry as a cause, and three types of misjudgment were noted about equally (less than 10 percent for each of these). "No signal" was mentioned somewhat more frequently, "unexpected maneuver," "inattention" and "speed" were mentioned most frequently, the latter two in almost 25 percent of the reports.

From no opinion to three causes for a given occurrence were reported by the different individuals.

These opinions, of course, cannot be taken at face value. It is of interest to compare them with the characteristics reported in describing the incidents and with those tabulated by the analyst in his independent review of the "near accidents" from the descriptions.

ANALYSIS OF BEHAVIOR AND CONDITIONS DESCRIBED

The characteristics described above gave the usual wide scatter of physical conditions and driver behavior which was not too enlightening. A further analysis of certain physical and behavior factors thought to be of probable importance was, therefore, undertaken. The attempt was made to include combinations of these factors rather than to classify into a single cause thought to be most important. The item on "hurry" was from the check list section of the report form. The other items were obtained by reviewing an abstract of the described occurrence and, in a large number of the cases, referring also to the original description.

BEHAVIOR ANALYSIS RESULTS

Number of Factors and Combinations

Only 2 of the 179 incidents reported could be classed as resulting from a single factor alone and even these might include other factors. These involved drivers apparently asleep or intoxicated who drifted off the road under conditions making improbable a collision with the reporting driver or anything else.

All other "near accidents" involved from 2 to 7 broad groups of factors operating simultaneously. Again the exact number depends on a judgment by the analyst.

Analysis Categories

Hurry	Driver Attitudes
Misjudgment Factor	Attention Factors
Unexpected Reaction	Fatigue, Sleep, Intoxication
Speed of Maneuver	Time of Day
Visibility	Essentials of Maneuver
Wet or Icy	Remedial Action
Highway Design Factor	Vehicle Maintenance Factor

It will be seen from the tables which follow that several of the seven factors included as many as 10 or 12 conditions or types of behavior. When it is considered that two such factors of 10 and 6 subdivisions, respectively, result in 60 combinations and that

TABLE 11

REPORTS OF "HURRY"

	Incidents Reported by				Drivers Involved	
	Private Drivers		Commercial Drivers	All Incidents	In Hurry	Not in Hurry
	Men	Women				
"In a hurry"						
Both drivers	16	3	6	25	50	-
Reporting driver only	12	1	2	15	15	15
Other driver only	41	2	26	69	69	69
Incidents involving hurry	69	6	34	109		
Neither "in a hurry"	50	4	16	70	-	140
Totals	119	10	50	179	134	224

adding a third factor with 10 categories results in 600 possible combinations, it is readily seen that the possible different combinations represented by 7 such factors are very numerous indeed.

Since this was not too large a sample of "near accidents" and other accident causing factors and combinations might be found in another sample. Thus it is easy to see why research on the causes of automobile accidents has been baffling, why combinations of behavior and of external conditions must be considered in research studies, and why classification into a single cause for each accident has failed to uncover basic causes satisfactorily.

HURRY HYPOTHESIS

From certain known results in experiments on judgments and from some practical opinions was derived the hypothesis that "hurry" on the part of one or more drivers might affect importantly the efficiency of driving behavior. Such "hurry" might be related to high speed or "speed too fast for conditions" or it might be independent of actual speed. It might have an effect on judgment, attention, foresight and planning in relation to both expected and unexpected situations. In order to test this hypothesis, a question on the report form asked whether the reporting driver himself was "in a hurry" and whether the other driver was judged to be "in a hurry" or not.

The behavior analysis was made separately for those cases with one or both drivers indicated as "in a hurry" and for those not so indicated. Analysis was carried out separately for men and women private drivers and for commercial drivers. The small number of women drivers and the range of factors led to combining data for all private drivers in many of the tables.

"Hurry" and "Near Accidents"

Each reporting driver was asked to note whether he himself was "in a hurry" at the time and whether or not other drivers were. His estimate on the other driver might or might not be related to his own "hurry" or "non-hurry."

Table 11 shows the total incidents reported as involving one or both drivers "in a hurry" by men and women private drivers and by commercial drivers. The column headed "all incidents" shows that 109 out of the 179 incidents involved drivers "in a hurry." The last two columns indicate that 134 of the drivers involved

TABLE 12

HURRY OF REPORTING DRIVER COMPARED WITH OTHERS

Contingency Table			
Other Driver	Reporting Driver: In Hurry	Reporting Driver: Not in Hurry	
In hurry	25 (21)	69 (73)	94
Not in hurry	15 (19)	70 (66)	85
Totals	40	139	179

Chi-square = 2.06, Df = 1, P =>.10

were "in a hurry" and the remaining 224 were not so reported.

"Hurry" or "non-hurry" on the part of the reporting driver apparently did not influence reports on "hurry" of "other" drivers. Table 12 shows a contingency analysis which tests whether the numbers of "hurried" and "non-hurried" drivers in the four cells differ from an expected figure based on the proportion within the other group. A difference from the expected figures greater than might occur by chance would indicate either a positive or negative relationship between the reports on "self" and on the "other" driver. No such statistically significant difference was found.

However, over half of the "other" drivers in near accidents were reported "in a hurry." Is this a greater number than might occur by chance meeting of "hurried" and "unhurried" drivers on the road? Table 13 gives the results of a test of this question. The proportion of all drivers "in a hurry" was used as an estimate (even though one which may be biased—see below) of the proportion of such drivers on the road. The probability of "hurried" and "unhurried" drivers meeting by chance was used to compute expected numbers of near accident incidents (Expected A). Comparison of the actual with the chance expectancy figures showed more "hurry" among "other" drivers and less among those reporting than expected. The probability of obtaining such a difference by chance would be less than one in a hundred.

If there is the relationship between "hurry" and "near accidents" it may well be that the sample included a larger proportion of drivers "in a hurry" than the driving population at large. Therefore, a second figure (Expected B) was computed using a slightly lower proportion, i. e., one third. Results showed even more cases of "other" and "both" drivers above expectancy and a greater statistical significance.

These tables show that a large proportion of incidents involving drivers "in a hurry" means nothing of itself since the chance expectancy figures gave a similar over-all relationship. However, the greater than expected frequency of "other" drivers "in a

TABLE 13

INCIDENTS INVOLVING HURRY COMPARED WITH CHANCE EXPECTANCY BASED ON PROPORTION OF DRIVERS IN A HURRY

Reported	Total Incidents	Expected A	Difference	Expected B	Difference
"In a hurry"					
Both drivers	25	25	0	19. 89	5. 21
Reporting driver only	15	42	-27	39. 78	-24. 78
Other driver only	69	42	+27	39. 78	29. 22
Neither	70	70	0	79. 55	9. 55
Totals		179		179. 00	
Chi-square =			34. 7		39. 42
Df =			1		1
P =			<. 01		<. 01

Expected Number of Incidents Including

Other Driver	Reporting Driver: In a Hurry	Reporting Driver: Not in a Hurry
In a hurry	$P1^2 . N$	$P1\ P2 . N$
Not in a hurry	$P1\ P2 . N$	$P2^2 . N$

Where: P1 = proportion of all drivers "in a hurry"
P2 = proportion of all drivers "not in a hurry"
N = number of incidents

Expected A based on $P1 = \frac{134}{358}$; $P2 = \frac{224}{358}$ = sample proportions

Expected B based on $P1 = \frac{1}{3}$; $P2 = \frac{2}{3}$

TABLE 14

POOR VISIBILITY, SLIPPERY SURFACE, AND ROAD DESIGN

Condition	Incidents Involving Drivers		
	In a Hurry	Not in a Hurry	Both
Poor visibility (rain, fog, glare, angle of view, etc.)	23	15	38
Surface wet, slippery, icy	11	7	18
Road design factors (cross road on curve, sight distance, long no passing zone, dip, narrowing pavement)	44	17	61
Totals	78	39	117

TABLE 15

UNEXPECTED BEHAVIOR OR CONDITION

Condition	Incidents Involving Drivers		
	In a Hurry	Not in a Hurry	Both
Other driver's behavior:			
Slowed or stopped suddenly	12	8	20
Ran through red, stop turn or sign	11	1	12
Sudden turn, no warning	1	6	7
Turn opposite signal or from wrong lane	4	1	5
Faced by vehicle on wrong side	3	1	4
Sudden start from parked position	3	1	4
Sudden cut-in ahead of car	4	4	8
Passed car swerved	1	1	2
Behavior of animal or pedestrian:			
Animal or child ran onto road	1	4	5
Unexpected condition:			
New stop sign, new intersection	0	2	2
Blind crossing, train across road	0	1	1
Car without lights, dark night	1	0	1
Totals	41	30	71

hurry" may be of significance and may indicate it as one factor in some types of "near accidents."

FACTORS IN CAUSAL COMBINATIONS

Possible relationships to "hurry" were investigated by tabulating other factors under a breakdown of "hurry" and "not in a hurry" (see Tables 14-18). To show a possible relationship to "hurry" the factor in question must occur in greater proportion than the ratio of total "hurry" to "non-hurry" incidents.

Table 14 shows that poor visibility, slippery surface and road design were judged of importance in 117 out of 179 incidents when taken in combination with other factors. Very few of these factors alone probably would have been sufficient as a cause. Note that "road design factors" (e.g., restricted sight distance, long no passing zone etc.) were a factor in more "hurry" accidents than the over-all 2 to 1 ratio would lead us to expect.

Table 15 shows 12 types of unexpected behavior or conditions which in combination with other factors appeared of causal importance. Again no one of these would have been sufficient alone. It will be noted that the largest group was sudden slowing or sudden stopping. Only "running through the red," etc., was markedly greater for "hurry" incidents.

Factors of inattention, sleep and intoxication shown in Table 16 again indicated a range of conditions. Note that "probably inattentive" and "not alert" taken together and the category "distracted by passengers" were the two largest groups. Here the total incidents "in a hurry" and "not in a hurry" show about the 2 to 1 relationship of the sample and, therefore, indicate no particular relationship between "hurry" and these variables. The possible exception is "distracted by passengers" but 13 of these cases were reported by bus drivers. This probably represents a special problem introduced by other activities required of such drivers rather than a relationship to "hurry."

An analysis of misjudgment, errors of perception and "confusion" resulted in Table 17 which presents 10 more behavior sub-divisions which in combination with other factors were judged to be of causal significance. The totals for "hurry" and " not in a hurry" are in about the proportion of the total sample. However, judgment of passing

TABLE 16

INATTENTION, SLEEP AND INTOXICATION

Condition	Incidents Involving Drivers		
	In a Hurry	Not in a Hurry	Both
"Not alert," "asleep at the switch," etc.	7	3	10
Distracted by passengers, conversation, thinking of something else	20[a]	8	28
Attention on signal, crossroad, etc., and "did not see car"	3	0	3
Probably inattentive	8	5	13
Asleep, fatigued, drowsy	5	4	9
Intoxicated	2	1	3
Probably drowsy or intoxicated	3	5	8
Totals	48	26	74

[a] 13 of these were reported by bus drivers.

TABLE 17

MISJUDGMENT, ERRORS OF PERCEPTION, CONFUSED

	Incidents Involving Drivers		
	In a Hurry	Not in a Hurry	Both
Misjudged:			
Speed of turn or curve	3	1	4
Speed and rate of closing	6	4	10
Passing opportunity	13	1	14
Other driver's intended action	7	6	13
Slippery road condition	1	3	4
Seriousness of hazard	15	6	21
Illusory effects of relative speed, car hidden in dip, misinterpreted officer's signal	4	0	4
Confused by inadequate signs, construction, complex intersection, etc.	2	2	4
Semi-sleep, confused, wrong reaction	0	1	1
Poor choice of procedure (slippery, afraid to pull off, trailer on ice, blocking bus instead of to bus stop)	1	3	4
Totals	52	27	79

TABLE 18

ATTITUDES, EMOTIONAL BEHAVIOR AND DRIVING HABITS

	Incidents Involving Drivers		
	In a Hurry	Not in a Hurry	Both
"Pushing through"	43	4	47
Competitive (accelerated when passed)	1	0	1
Expected and took right of way (did not observe stop sign on through street, etc.)	1	3	4
"Irresponsible," or unaware of hazard	2	2	4
Faulty driving habits	9	9	18
Emotional behavior	3	1	4
Totals	59	19	78

opportunity, seriousness of hazard, and possibly one or two others show a sufficiently greater proportion to be of possible significance. For both groups together misjudgment of "speed and rate of closing" and of "other driver's intention" were also among the most frequent factors.

Analysis of reported attitudes, emotional behavior and driving habits shown in Table 18, contributed another 6 sub-categories. The table shows that for both groups together behavior classed as "pushing through" was the most frequent and that classed as "faulty driving habits" was second. Note also that "pushing through" was so disproportionate as to represent a highly probable relationship to drivers "in a hurry."

It is significant that these categories occurred in combination with speeds of 15 to 30 mph as well as with speeds on the open road under 50 and at 50 to 60 mph. Thus, it is clear that this attitude and its relationship to "hurry" were not at all the same thing as driving at high speed. Although this behavior occurred in some of the cases noted as "too fast for conditions" it also occurred in many other cases where speed as such was not given as a major factor in the description of the accident.

This characteristic picture of "pushing through" may have been one basis on which some reporting drivers checked the other driver as being "in a hurry." For reports of "hurry" on their own part, however, this was not the case and certainly not in cases where they checked neither driver "in a hurry."

The following examples of behavior classified as "pushing through," "emotional behavior" and "faulty driving habits" will indicate kinds of behavior included:

Examples of Behavior Classed as "Pushing Through"

Oncoming car passed line of traffic against oncoming traffic.
Ran red signal or stop sign, squeezed through cross traffic, almost collided.
Truck crossed center line to pass car stopped for left turn.
Was passing and weaving in heavy traffic.
Passed on upgrade with oncoming traffic.
Passed on right when truck slowed to turn into driveway.
Made overtake on rise and dip in face of oncoming car.
Started before signal changed.
Passed with oncoming car close.
Turned corner in front and from left of starting bus.
Crossed main highway, squeezed between bus and truck travelling fast on latter (opposite directions).
Followed close, impatient to pass, squeezed by forcing other cars to stop or dodge by such maneuvers.

Examples of Behavior Classed as "Emotional"

Woman driver stopped on tracks in front of oncoming train to pick up an injured dog—then into a car and backed without looking into standing truck instead of proceeding ahead on open street.

Dashed into traffic from gas station—started engine in gear, shot out onto street—claimed due to upset from fight with wife.

Apparently angered, made hazardous pass, turned and glared. Later dashed into main highway between opposite fast approaching heavy vehicles.

Examples of Behavior Classed as "Faulty Driving Habits"

Stopped suddenly in traffic without signal.
Signalled turn after starting turn.
Looked back (for considerable period) while making pass or turn.
Did not check to rear before starting pass or turn.
Turned from wrong lane on multilane highway.
Travelled with wheel over center line.
Followed too close to large vehicle to see ahead.
Pulled into traffic from shoulder in front of fast traffic.
Started from curb while looking at passenger.
Changed mind (and direction) after starting a turn.
Combinations, e. g., turned from wrong lane without checking traffic from rear.

COMBINATIONS OF FACTORS

Although all possible combinations indicated earlier could not occur in our small sample of "near accidents," the very large number of combinations which did occur made it impractical to determine those most frequently found. It would be necessary to carry out a special study with a very much larger number of cases than this one in order to make such a determination.

The following illustrations, however, will perhaps show how the combination of factors may cause a "near accident" (and possibly an actual accident) although no one of the factors would be sufficient.

Example 1—Icy Road, Siren Not Heard, Misunderstanding or Misjudgment

Two cars approaching intersection at right driver angles, both at relatively slow speed, icy highway—one vehicle, an ambulance, other driver did not hear the siren, misunderstood the traffic officer's signal. The officer "ran for his life"—ambulance and car both tried to stop, skidded, missed each other.

Example 2—Slow Vehicle, Vehicle Condition, Driving Habit or Frustration, Error or Delay of Perception

Reporting driver traveling from 45 to 50 mph, met line of cars following truck, passing car with one head light out, glare, long "no passing" zone. Reporting driver raised own headlights, saw the oncoming pass, took to the shoulder and "missed by inches."

Example 3—Highway Design, Driving Habit, Inattention or Misjudgment by Each of Three Drivers

Reporting driver on rural highway, coming over hill which limited sight distance, saw two vehicles parked on right shoulder and a truck coming in opposite direction. One parked vehicle pulled onto the highway apparently not having seen the reporting driver approaching. The latter had misjudged other's intent and did not sound horn. He was able to brake just enough to let the truck by and pass the slow car without collision.

Example 4—Curve, Grade, Night, Drowsiness, Hurry

Reporting driver at 40 mph met car coming downhill on curve at night—other driver apparently drowsy, gradually veered into opposing lane—recovered enough to miss when reporting driver frantically blew horn and pulled right as far as possible. Other driver rated as "in a hurry."

Example 5—Night Visibility, Judgment of Speed, Hurry

Reporting driver halted at stop sign, night, no street light—car at left curb starting from parked position, did not perceive motion—looked to right and started slowly, braked hard as other driver "pushed through" in front of him.

DISCUSSION

Although probably not a representative cross section of all accidents in the country, the sample reported does give an indication of the range of causal combinations responsible for motor vehicle accidents. A research method is illustrated which could be used on a more extensive scale to obtain a more representative cross section.

One great advantage of the method is that it allows those reporting to indicate objectively factors which were of importance in causing the "near accident" event. The analyst, therefore, has a basis for eliminating a mass of irrelevant factors which are often included in large sample mass statistics. Such irrelevant factors may mask the actual causal combinations.

Factors favoring memory and recall of certain accidents rather than other may affect the incidents reported. For instance, dramatic happenings may tend to be recalled more often. Even so, certain factors which resulted are of significance and should be investigated further.

A larger than expected number of "hurry" ratings of "other" drivers and an unduly high proportion of certain types of misjudgment involving drivers "in a hurry" suggests very strongly that such a state of mind may be an important component of many accident causing constellations. Similarly the extremely high proportion of "pushing through" behavior is an important factor. It may be that this behavior was in many cases the indication upon which a rating of "hurry" was based.

It may be significant that "faulty driving habits" also occurred in the causal combinations with fairly high frequency.

Although we have pointed out certain groups of behavior characteristics which occurred most frequently in this particular group of reports, many additional components and combinations might be found in other samples of near accidents reported by another group or from other areas.

CONCLUSIONS

1. Although this study includes a relatively small and selected sample of "near accidents" its results can be of importance in indicating a wide range of possible causal combinations and in suggesting a method for further research.
2. A wide range of driver characteristics such as occupation, age, etc., were involved in the "near accident" incidents. Thus a wide range of types of "near accidents" and a wide range of ages of reporting drivers was included.
3. The sample of reporting drivers was definitely a selected one including clerical, professional and semi-professional people and many with a special knowledge and interest in traffic. This selection resulted from committee distribution of report forms to those interested and able to turn in reliable and meaningful reports. "Other drivers" in the "near accidents " however, should include a more random group of drivers.
4. The results suggest that certain types of driver judgments and behavior may be affected by "hurry" which may be of importance as one factor in accident causing factor combinations.
5. Behavior classed as "pushing through" was described in many incidents involving drivers rated as "in a hurry."
6. Only two of the accidents could be blamed upon a single causal factor alone and even these might include other factors. The remainder of the 177 involved from 2 to 7 categories of driving behavior and environmental conditions. A slight variation of any one of these might have changed the incident to an accident. Each of these classifications included from 6 to 12 sub-divisions of behavior or conditions, thus resulting in many thousands of possible combinations of factors in causal constellations.
7. This large number of causal combinations explains the general lack of success of

attempts to find a single cause for each traffic accident (which has been so widely used).

8. Much research is needed to analyze the widely different combinations of behavior and conditions which may get drivers into trouble. Scientifically valid information on such combinations of causal behavior and other factors which will forewarn drivers of hazards which they otherwise may not appreciate until suddenly met on the highway. It may also point out components of importance which can be affected by remedial engineering or enforcement approaches.

Appendix

To Those Cooperating in the Study:

It is well known that investigation of accidents can yield information as to their causes, but in some instances a person who has a near-accident may be more aware of what happened than drivers in an actual accident. This may be especially true with regard to behavior factors such as attention, vision, judgments and so on. Your cooperation is requested, therefore, in a preliminary study to see whether the reports of a selected group of drivers regarding near-accidents will yield useful information as to causal factors.

Most people have had at least a few occasions where they just missed being involved in a bad accident on the highway. Please recall, if possible, five or six of these with the most serious probable consequences.

Please fill in the blanks at the bottom of this sheet. Then describe briefly each near-accident on one of the blank forms attached, and mail in the self-addressed envelope. Sample description and 5 blank forms are enclosed for your use. All names will be kept confidential and any report of results will be anonymous.

Thanking you for your assistance, we remain

Sincerely yours,

Road User Characteristics Committee
of the Highway Research Board
T. W. Forbes, Chairman

Your Name____________________________ Age (Last Birthday)________

Occupation____________________________ Total Driving Experience____

City________________________ State____________________________

1. Letter of instructions.

S A M P L E

DESCRIPTION OF NEAR-ACCIDENT

Name x x x x x x x x x x x x
(confidential - for analysis only)

A. Please describe briefly what happened, including any important features of vehicle, highway, visibility and human factors which were involved.

Occurred on 4-lane, undivided highway in suburban area, clear, dry, good road, about 5:30 P.M. and getting rather dark. Peak hour traffic fairly heavy outbound (my direction). I was making left turn on green at signalized intersection across light opposing traffic. Thought I had plenty of time between two oncoming cars and started turn from my side of center line as required. Difficult to see intersection. Found I had turned a bit too soon and would hit center island of street I was entering—also discovered pedestrians crossing. Therefore I was forced to lengthen turn and slow down.

Oncoming car probably coming at about 50 mph (about average for this road), suddenly loomed up about to hit me broadside, blaring his horn but not slowing. I stepped on the accelerator and crowded the center island, he stepped on his brakes at last moment and skidded past my rear bumper just missing it.

B. In your opinion, what were the factors of most importance in producing this particular near-accident? (physical or human, or both)

Poor visibility of intersection and pedestrians; misjudgment of intersection location possibly from illusion due to angular overhead arrangement of two signals mounted on wire spanning highway at 45 degrees; glare from headlights and lack of intersection lighting; possible misjudgment of speed of oncoming car by me (but I don't think so); either hurry on part of other driver or conviction that he had complete right of way (since he used his horn rather than braking earlier).

C. Please check the following in relation to this particular near accident.

Remarks

1. Were you in a hurry at the time? Yes ☐ No ☒ ____________
2. Was there evidence that other drivers involved were in a hurry? Yes ☒ No ☐ Evidence indirect
3. Was your attention—
   Highly concentrated—on traffic? ☒ on something else? ☐ ______
   Distracted by several things? ☐ ____________
   Neither? ☐ ____________
   Do not remember ☐ ____________
4. Approximate time 1 months ago / years ago; Fall (season); P. M. twilight (A. M., P. M., Twilight, night, day)

2. Example of use of report form.

DESCRIPTION OF NEAR-ACCIDENT

Name ______________________
(Confidential - For analysis only)

A. Please describe briefly what happened, including any important features of vehicle, highway, visibility and human factors which were involved.

B. In your opinion, what were the factors of most importance in producing this particular near-accident? (physical or human, or both)

C. Please check the following in relation to this particular near accident.

Remarks

1. Were you in a hurry at the time? Yes ☐ No ☐ ______________
2. Was there evidence that other drivers involved were in a hurry? Yes ☐ No ☐ ______________
3. Was your attention—
   Highly concentrated—on traffic? ☐ on something else? ☐ ____
   Distracted by several things? ☐ ______________
   Neither? ☐ ______________
   Do not remember ☐ ______________
4. Approximate time _____ months ago / years ago _____ season _____ A. M., P. M., twilight, night, day

3. Report form blank.

THE NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL is a private, nonprofit organization of scientists, dedicated to the furtherance of science and to its use for the general welfare. The ACADEMY itself was established in 1863 under a congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the federal government in scientific matters. This provision accounts for the close ties that have always existed between the ACADEMY and the government, although the ACADEMY is not a governmental agency.

The NATIONAL RESEARCH COUNCIL was established by the ACADEMY in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the ACADEMY in service to the nation, to society, and to science at home and abroad. Members of the NATIONAL RESEARCH COUNCIL receive their appointments from the president of the ACADEMY. They include representatives nominated by the major scientific and technical societies, representatives of the federal government, and a number of members at large. In addition, several thousand scientists and engineers take part in the activities of the research council through membership on its various boards and committees.

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