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Contents

Development of a Criterion for Driving Performance

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● DURING the several years that driving researches have been in progress, experimenters have felt the need for a sound criterion of driving ability. Different investigators have used various types of criteria. None have been found completely satisfactory.

The ordinary road test as a criterion has been found by Lauer and others (2) to have low reliability. Even those who originally developed this test have never published anything which indicates the statistical reliability of the test. Neither has anything been done to show its validity.

The Adjutant General's Office of the Army has done a great deal to develop various types of criteria for the Armed Forces. One of the studies which has been published describes a well developed criterion of driving ability. (3) It is based on ratings by associates and superiors. While satisfactory for the purpose devised it would be rather impractical and difficult to administer under civilian conditions due to the lack of a sufficient number of persons familiar with the driver's performance at the wheel who could rate the driver.

The criterion of reported accidents has been found quite unreliable. Even over successive periods Johnson (1) found correlations as low as .30 for the same drivers in two successive epochs. Various explanations may be given. First, there is very little chance of being caught in a violation or accident, and second, there seems to be a psychological effect which follows being involved in an accident. The precise effect seems to be differential. For most drivers it has a deterrent effect. For a few persons it is indicative of future behavior with similar results. Intercorrelations of rating scales, as well as laboratory devices designed for measuring certain aspects of driver performance, were made. The hypothesis set up for testing may be stated as follows: patterns of behavior relating to good driving performance are measurable.

METHOD AND PROCEDURE

This is a four-phase study of driver performance designed to establish a basis or criterion of driving ability. Each subject was given a simulated driving test in the laboratory under controlled conditions. The second test was that of driving an instrumented car over an 8-mile standard route. A tachograph record was obtained for each subject while the trip was being made. The road driving performance was rated by means of the Roger-Lauer Scale. Three hundred forty-nine subjects were used. They included commercial drivers, lay drivers, and students just completing a driver education course.

The Roger-Lauer Scale

This is a paper and pencil rating scale first developed in 1938. It is divided into two parts. Each part is scored separately and the two combined for a total score.

Part one covers twelve behavior categories assumed to be largely inherent. There are five descriptive phrases in each category. The rater checks the phrase which he thinks is most characteristic of the rates. Each phrase has a numerical weighting. The sum of the numerical weightings constitute the score.

Part two is concerned with the degree of skill shown in performance of certain functions deemed basic to efficient automobile driving. It consists of 15 items which are rated on a seven-point scale. The sum of the scale point values constitutes the score.

This scale was originally reported to have a reliability of the order of .90. Split-

TABLE 1

RELIABILITY OF RATINGS ON ROGER-LAUER SCALE

	Students[a]		Experienced Drivers[b]		Total Group[c]	
	r_{12}	r^d	r_{12}	r^d	r_{12}	r^d
Part 1	.76	.86	.57	.73	—	—
Part 2	.76	.86	.72	.84	—	—
Total score	—	—	—	—	.85	.92

[a] Based on 231 cases
[b] Based on 118 cases
[c] Based on 349 cases
[d] Estimated full-length reliability using the Spearman-Brown formula

TABLE 2

INTERCORRELATIONS OF TACHOGRAPH AND ROGER-LAUER SCALE DATA

	1	2	3	4	5
1. Trip time	—	-.6920	-.6590	.5640	-.2690
2. Modal speed		—	.8290	-.4970	.2000
3. Maximum speed			—	-.5050	.1350
4. Number of fluctuations				—	-.0003
5. Roger-Lauer Scale					—

A correlation of the Tachograph measurements with the Roger-Lauer Scale rating yielded a multiple R of .3375 which shrank to .3178 when corrected for the number of cases and number of variables.

On a rational basis from the magnitude of the betas it would seem that (1), (2), and (4) of this matrix should be considered in the final evaluation phase of this study.

TABLE 3

RELIABILITY OF DIFFERENT SCORES ON THE AUTO TRAINER[a]

	r_{12}	r^b on sum of test-retest scores
Steering (contacts)	.52	.68
Total time (minutes)	.75	.85
Response time (milliseconds)	.48	.66
Movements (total recorded)	.48	.66
Errors (practices violated and mistakes made)	.73	.84

[a] Based on 150 cases at Iowa State College
[b] Estimated reliability of a test-retest score using the Spearman-Brown Formula—scores added together.

half reliabilities were computed from the ratings made in this study. The resulting coefficients for part one, part two, and total score are shown in Table 1.

Tachograph

The Sangamo Model AA 12-hour Tachograph was used. In addition to containing a speedometer, odometer, and clock, this instrument makes a graphic recording of fluctuations in speed, total trip time, and miles traveled. A sample tachograph chart is shown in Figure 1.

An analysis of each trip was made by means of the tachograph chart analyzer shown in Figure 2. Trip time, modal speed, maximum speed and number of fluctuations were determined.

The intercorrelations of the various factors measured by the tachograph together with their correlations with the Roger-Lauer Scale ratings are shown in Table 2.

A multiple correlation of .3375 was obtained between the four tachograph variables

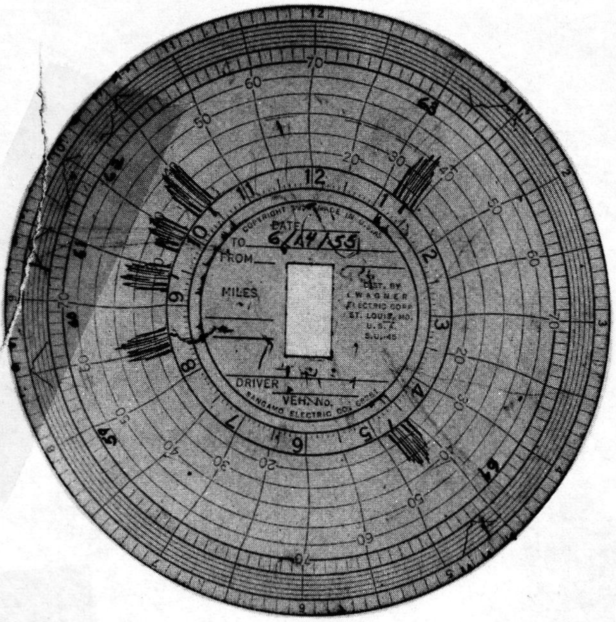


Figure 1. Tachograph Chart.

Record made on the Sangamo 12-hour Tachograph. Six short drives are shown. The following factors are measured by the Tachograph Chart Analyzer shown below: maximum speed, modal speed, fluctuations in speed, total trip time, and miles traveled.

A multiple R of .33 was obtained with the Roger-Lauer Rating Scale as the criterion.

Other factors could be measured as thought advisable. It would appear that a great deal of valuable information about drivers could be obtained from a scientific analysis of their records.

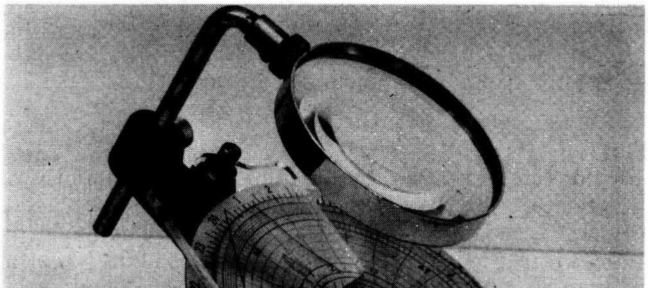


Figure 2. Tachograph Chart Analyzer.

Figure 3. Model B Auto Trainer.

AAA Model B Auto Trainer is used as a laboratory test and training device. The various factors measured are (1) steering efficiency, (2) errors made in manipulation, (3) reaction or response time to a red signal light, (4) extent of movement made and (5) time for the trip.

As a testing device it correlates .45 with road driving as rated by the Roger-Lauer Scale. This scale has a reliability of .92.

As a training device it can be used singly or in any reasonable number of units. For small schools, multiples of four units are recommended. The first four lessons in fundamentals of driving can be taught much more economically than in a car. Extra practice can be given without risk at the student's convenience.

and the Roger-Lauer Scale rating. The shrunken R was .3178.

Auto Trainer

This is a laboratory device developed by the American Automobile Association for purposes of driver instruction. Full-size automobile controls are used to guide a miniature car around a traveling roadway simulating driving. The Model B Auto Trainer used in this study is shown in Figure 3. It may also be used as a testing device.

The device is designed so as to yield several subscores. They are (1) steering efficiency or the ability to stay on the road, (2) response time to traffic lights as presented, (3) errors in manipulation or such failures as not following directions and road signs, (4) movements made in braking, shifting, etc., and (5) total time for the trip of a given number of revolutions of the roadway belt. All recordings are made automatically by a battery of electric counters.

The conditions were standard for all subjects. They included use of clutch, brake and accelerator, steering wheel, driving forward and backward, and parking. Observation of signs and other features of the device simulate actual road-driving conditions and are controlled to some extent.

Table 3 contains the test-retest reliability coefficients for the various scores on the Auto Trainer.

The intercorrelations of the Auto Trainer scores are listed in Table 4. Correlations with the Roger-Lauer Scale ratings are also included in this table. The six Auto Trainer scores yielded a multiple correlation of .4503 with the Roger-Lauer Scale rating. The corrected R shrunk to .4289.

TABLE 4

INTERCORRELATIONS OF AUTO TRAINER SCORES AND ROGER-LAUER SCALE RATING

	1	2	3	4	5	6	7
1. Steering	—	-.3120	.1050	-.2960	.1710	.2080	.1480
2. Errors		—	.2150	.1840	.1780	-.2270	-.2170
3. Movements			—	-.0090	.4350	-.1600	-.1360
4. Observation time				—	.0520	-.1140	-.0400
5. Total trip time					—	-.2540	-.3610
6. Hand brake pressure						—	.2660
7. Roger-Lauer Scale							—

A correlation of the Auto Trainer scores with the Roger-Lauer Scale rating yielded a multiple R of .4503 which shrank to .4289 when corrected for the number of cases and number of variables.

On a rational basis from the magnitude of the betas it would seem that (1), (2), (5), and (6) of this matrix should be considered in the final evaluation phase of this study.

Car Instrumentation

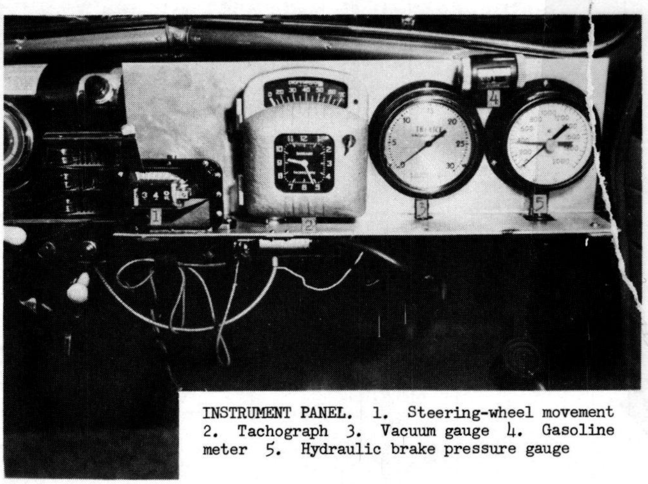
An Oldsmobile hydramatic drive, four-door sedan equipped with instrumentation designed to objectively measure driver performance with respect to certain factors deemed relevant to efficient operation of a motor vehicle was used for the road tests.

On a panel just back of the dashboard at the right side the following instruments are mounted from left to right as shown in Figure 4.

1. Revco reduction gear and counter. It is used to integrate the total amount of steering-wheel movement made by the driver. The counter is attached to the reduction gear so as to make a continuous recording of the steering wheel movements in both directions. The reset counter is set at zero at the beginning of each trip. At the end of the trip the numerical reading is recorded as steering-movement score.
2. Sangamo Model AA Tachograph previously described.
3. Trerice vacuum gauge. The gauge is attached to a pressure chamber which is set to activate a counter whenever the carburetor vacuum pressure is equal to the setting. In this way a recording of accelerator movements is obtained.
4. Gasoline meter. A McCulloch gasoline meter was used to measure gasoline consumption in $\frac{1}{100}$ths of a gallon. The meter can be reset to begin accumulating from zero at the beginning of each trip.
5. Trerice hydraulic pressure gauge. Maximum pressure in pounds made on the brake pedal is measured and retained on this instrument by a special hand.

Other instruments are located in the rear seat area of the experimental car. They are shown in Figures 5 and 6.

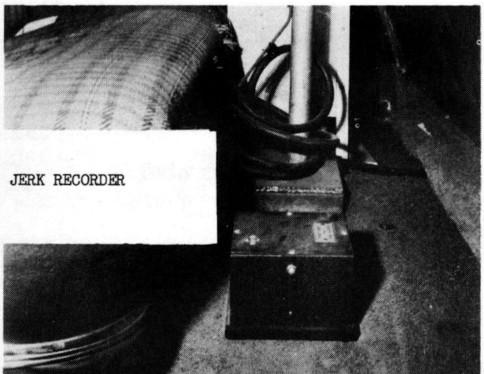
6. Accelerator movement counter. The counter is mounted on a panel built infront of the rear seat rest. It is connected to the vacuum gauge in such a way as to be activated every time the indicator hand of the gauge fluctuates above or below a preset reading.
7. Brake movement counter. This recording device is mounted just below the accelerator movement counter. It is connected to the stop light circuit so that it is activated every time the brake pedal is depressed thus recording brake applications.
8. Jerk recorder. The jerk recorder is housed in a steel cabinet measuring 4½ in. x 7½ in. x 5 in. high. A ½ in. steel shaft runs through the center of the cabinet near the top. Two pendulums each 4½ in. long are mounted to swing freely on this shaft.



INSTRUMENT PANEL. 1. Steering-wheel movement 2. Tachograph 3. Vacuum gauge 4. Gasoline meter 5. Hydraulic brake pressure gauge

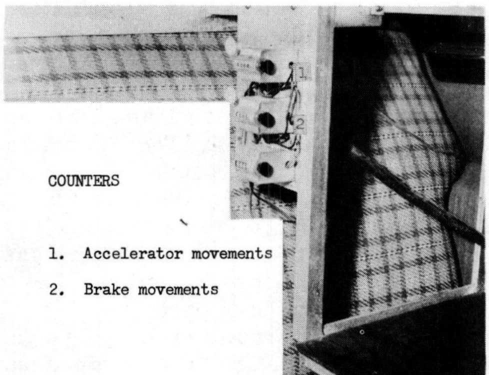
Figure 4.

TOP. Instrumentation on dash of the experimental test car for drivers. (1) Revco reduction gear with attached counter measures the amount of steering done over a given route. (2) The Sangamo Tachograph yields a number of measures including fluctuations in speed, total trip time, and miles traveled. (3) Accelerator movements are measured by a Trerice vacuum gauge. (4) The McCulloch gasoline meter gives the gasoline consumption in hundredths of a gallon. (5) Braking is recorded by the Trerice pressure gauge. The maximum indicator hand reading is recorded. Electric counters are also attached to (3) and (5) to give accumulative records.



JERK RECORDER

Figure 5.



COUNTERS

1. Accelerator movements
2. Brake movements

Figure 6.

On the center of the shaft between the two pendulums is an assembly consisting of two brass ratchets each with 60 teeth and a sprocket wheel with 20 teeth.

When a stop is made one pendulum swings forward turning one of the ratchets by means of a small pawl. The sprocket wheel turns with the ratchet and operates a mechanical counter. Each 18 degrees of rotation of the pendulum counts one unit on the counter. A movement of six deg. causes the counter to record ⅓ unit. The other pendulum is arranged so that it moves when a sudden start is made and operates in a similar manner but with different settings for sensitivity.

Two of these instruments are used. One is placed lengthwise with the car so as to record sudden stops or quick starts. The other is placed crosswise with the car so as to measure sway from side to side. It is set to register slighter movements, that is, made more sensitive. Both instruments are placed on the floorboard in front of the rear seat.

Split-half reliability of the data gathered by the various instruments in the experimental car is shown in Table 5.

TABLE 5

RELIABILITY OF EXPERIMENTAL CAR INSTRUMENT SCORES[a]

	r_{12}	r^{b}
Steering movements	.54	.70
Gasoline consumption	.62	.77
Accelerator movements	.70	.83
Brake movements	.42	.59
Brake pressure	.48	.65
Jerk recorder (lengthwise)	.70	.83
Jerk recorder (crosswise)	.56	.72

[a] Based on 349 cases
[b] Estimated full-length reliability using the Spearman-Brown formula

TABLE 6

INTERCORRELATIONS OF EXPERIMENTAL CAR, INSTRUMENT SCORES AND ROGER-LAUER SCALE RATING

	1	2	3	4	5	6	7	8
1. Gasoline consumption	—	.3220	.1970	.0780	.1600	.0080	.0090	-.1030
2. Steering movements		—	.2630	.0710	.3870	.1050	.1730	-.5210
3. Brake pressure			—	.1490	.0780	.1220	.1620	-.1940
4. Brake movements				—	.2410	.1720	-.1220	.0510
5. Accelerator movements					—	.2240	.0690	-.2520
6. Jerk recorder (lengthwise)						—	.3760	-.2380
7. Jerk recorder (crosswise)							—	-.1760
8. Roger-Lauer Scale								—

A correlation of the Experimental Car instrument scores with the Roger-Lauer Scale rating yielded a multiple R of .5741 which shrank to .5603 when corrected for the number of cases and number of variables.

On a rational basis from the magnitude of the betas it would seem that (2), (4), and (6) of this matrix should be considered in the final examination phase of this study.

Intercorrelation of the scores obtained from the experimental car instruments together with their correlations with the Roger-Lauer Scale rating are presented in Table 6.

A multiple correlation of the instrument scores with the Roger-Lauer Scale rating was computed. R = .5741. This shrinks to .5603.

DISCUSSION

This is the first part of an extended study which is being made in an effort to develop an objective criterion of driving performance. The purpose of this portion of the study was to determine the reliability and validity of the various objective separate measures and to select the ones which seem to be most worthy to be included in the second part of the study which is to be reported later.

The Roger-Lauer Scale ratings were used as the primary criterion against which to evaluate the potential predictive value of the several objective scores. This scale was selected because it has sufficient reliability for individual use and provides an immediate criterion. It also samples behavior patterns as well as developed skills.

Two of the Auto Trainer subscores, namely total time and errors, seemed to possess sufficient reliability and validity to be retained for further study. These two measures with hand brake pressure correlated the highest with the Roger-Lauer Scale rating. Reliability of hand brake pressure was not computed. It was used more as an auxiliary measure in this study. From previous studies it would appear that steering movements should be retained for further evaluation.

Three of the tachograph variables seemed promising. They are trip time, modal speed, and fluctuations in speed. Modal speed correlated considerably higher with the Roger-Lauer Scale rating than did maximum speed.

Most of the instruments in the experimental car seemed to measure with sufficient consistency to merit their retention in the second part of the study. Accelerator movements and smoothness as measured by the jerk recorded as measuring lengthwise thrust of the car showed highest reliability.

The measurements from the four phases of the study showing satisfactory performance are to be combined into a multiple correlation with road driving performance rating in the second part of this study. The factors making the most significant contribution to the multiple R are to be used in development of an objective criterion of driving performance ability. From the data available it would appear that with these techniques combined it may be possible to measure from 70-90 percent of the variance in driving ability.

CONCLUSIONS

Considering the characteristics of the sample employed, number of subjects, and the nature of the results obtained, the following conclusions may be tentatively drawn from this study:

1. The Auto Trainer yields three subscores, namely, total time, errors, and steering which are sufficiently substantial to justify their use in further research in driver evaluation studies.
2. Analysis of tachograph records will give valuable information on driving ability. Further study needs be made of possible derived scores.
3. The AAA Jerk Recorder will reliably measure smoothness of movement when placed lengthwise with the car.
4. The better performing driver holds the wheel steadier, i.e., turns the wheel less, uses less gasoline, works the accelerator less and is less severe on the brake than the poorer performing driver.
5. Certain factors related to road driving performance can be substantially measured by means of scores objectively obtained while the driver is performing the task. Supplementary measures made by simulated driving devices will increase the predictive value of a battery designed for this purpose.
6. The hypothesis set up for testing—that driving performance can be objectively measured—is affirmed within reasonable limits of error.

ACKNOWLEDGMENT

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A Factor Study of Drivers' Attitudes, with Further Study on Driver Aggression

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BACKGROUND AND ORIENTATION OF THE STUDY

DRIVERS' ATTITUDES are a continuing problem in highway safety. There is much opinion (3, 7, 8, 10, 15, 27, 28, 30) and even some research (13, 16, 24, 25, 32, 34, 35) to support the notion that attitudes play an important role in driver behavior. And driver behavior plays an important role in highway fatalities and injuries. It is believed by many that if we could only build "proper" attitudes into drivers, we would go a long way toward making the highways safe.

But before we can begin to know how to develop "proper" attitudes it would seem essential that we find out first what it is we really should have in mind when we speak of drivers' attitudes. Attitudes toward what? Particularly, what are the basic variables (or dimensions) underlying drivers' attitudes? What are the primary attitude objects? How many are there? Are a drivers' attitudes all good or all bad, or is there variation within the individual from one attitude object to another? Is one generally careful or generally reckless, or are there a host of specifics?

Specific Objective of the Study

The present study was a first exploratory step in an effort to identify the basic variables, or dimensions, underlying drivers' attitudes. And the range of attitude objects is defined to encompass the various aspects of driving. Four factors (or dimensions) were hypothesized:

1. Appreciation of hazard. 2. Social responsibility or conformity. 3. Attitude toward the vehicle itself and its operation. 4. Attitude toward speed and speed limits.

General Plan of Investigation

The broad plan of the study consisted in three steps:

1. Development of an instrument (or instruments) to measure attitudes toward as many as possible of the various aspects of the driving activity: to cover the domain of interest.
2. Collection of data on the attitude measures on a group of drivers whose motivation to manipulate their responses could be minimized. (Attitude measures are almost universally easy to falsify by simply giving the response which is known or believed to be the socially desirable one.)
3. Factor analysis of the attitude measures, including rotation to psychological meaningfulness.

Development of the Instrument - The Drivers' Attitude Inventory

Three major considerations determined the nature of the instrument(s) to be prepared:

1. What are the objects of the driving situation, the attitudes toward which we wish to measure?
2. How are data to be collected - by interview, mail order, or direct administration of a standard form? On what kinds of drivers? How enlist their cooperation and circumvent the operation of facade?
3. The data must be amenable to some kind of factor analysis in order that dimensions may be identified.

A study of the available literature (3, 7, 8, 9, 10, 11, 12, 13, 16, 26, 28, 30, 31, 32, 34, 35) and consultation with people in safety work, led to the realization that the number of specific aspects of driving toward which drivers may have attitudes may be large indeed. Direct factor analysis of 100 or 200 variables seemed infeasible even if electronic computing equipment were available. A grouping into categories (or clusters) of attitude objects was necessary. Fourteen categories were finally settled on as covering the domain of interest in this study and being surely greater than the expected number of factors. They are presented in Table 1 along with the subheadings that define the clusters for this purpose and indicate the kind of attitude object being included.

TABLE 1

CATEGORIES OF OBJECTS OF DRIVERS' ATTITUDES

1. Speed
   a. In city
   b. On open-highway
   c. Satisfaction derived from driving fast

2. Other users of the roadway
   a. Other drivers (or vehicles)
   b. Pedestrians
   c. Children
   d. Slow drivers
   e. Misbehavior of other users

3. Causes of accidents
   a. Driver's behavior
   b. Road conditions
   c. Mechanical failure
   d. Fatalistic attitude

4. Rules and laws
   a. General conformity
   b. Authority
   c. Enforcement

5. Mechanical traffic controls
   a. Lights
   b. Signs

6. Driver limitations
   a. Age
   b. Use of alcohol
   c. Fatigue
   d. Speed of reaction

7. Cops
   a. Use of authority
   b. Fairness
   c. Interest in safety
   d. Courtesy vs abuse

8. Risk taking
   a. Recognition of hazards
   b. Probability of an accident
   c. Need for preventive (defensive) driving

9. Concept of the "Good Driver"
   a. Ability to make time
   b. Ability to get through traffic
   c. Consideration for others

10. The vehicle itself
    a. Identification with
    b. Enjoyment of operating it
    c. Symbol of status
    d. Maintenance, inspection, care

11. Driver training
    a. Need for special training
    b. Licensing exams

12. Responsibility
    a. To others on the highway
    b. For consequences of own actions
    c. To self as member of family or larger society

13. Passengers

14. Special driving conditions
    a. Night
    b. Bad weather
    c. Heavy traffic
    d. Unfamiliar place

One hundred eighty-eight attitude items were written to measure attitudes in the 14 clusters indicated. For example: Many traffic laws are entirely unreasonable; Most drivers who have accidents are just unlucky; It's a thrill to outwit other drivers. The 188 items were prepared in typed booklet form for a preliminary tryout designed to identify ambiguities and items on which drivers did not differ appreciably. Thirteen drivers well known to the investigator were asked to participate in a pilot study. Instructions provided five possible responses: Strongly agree, agree, undecided, disagree and strongly disagree. An IBM answer sheet was used to record responses.

Comments were solicited in regard to any ambiguities, objectionable items, double-barreled statements or any other difficulty encountered.

On the basis of this pilot run, 80 of the items were revised to some degree and two were discarded. Further valuable findings were as follows:

1. Use of a separate answer sheet is not efficient for other than monitored group administration with proper writing-desk surfaces.

2. To ask any one to respond to some 180 attitude items, each of which takes some thought, time, and soul-searching is asking much, even of friends, and only friends are likely to comply at all.

3. The burdensomeness of the task could be appreciably reduced by using only three categories of response: Agree, undecided, disagree.

Two of the findings were readily incorporated in the final form of the instrument: for each item three response boxes were provided in the booklet and plainly labelled Agree, Undecided, and Disagree. The possibility of reduction in number of items was a knottier problem in face of the desirability of retaining the full coverage of the 14 clusters. In any case, data (rather than judgment) would be needed for any item selection scheme, and if data were available the analysis could be done without prior selection. It was at this point that the choice was made in favor of obtaining data on a group of drivers whose motivation to participate without faking could be maximized over against using a properly determined random sample of drivers from the desired universe, but whose responses to attitude items would be expected to be badly biased by facade.

The instrument used in this study, then contained 186 items, and three possible response positions were provided for each. Instructions for self-administration were provided on the cover page. In addition, ten items of information were asked for: 1. name, 2. age, 3. sex, 4. years driven, 5. miles driven, 6. number of moving violations for which fined, 7. number of accidents, 8. number of accidents for which at least partly at fault, 9. cost of damage or injury in accidents for which partly at fault, and 10. present occupation.

Keying and Scoring of Items

Ideally the "correct" response to such attitude items would be that response which is associated with "good" driving behavior. Were it possible to obtain good criterion data on a very large sample, it might well be possible to key such items on the basis of the sign of the correlation coefficient. The prior history of validities of psychometric variables against accident data (5, 6, 9, 11, 13, 16, 17, 19, 21, 22, 24, 25, 32), or indeed of the unreliability of accident data (5, 11, 16, 17, 19, 22, 24, 25, 29, 32, 36, 37) did not indicate a great likelihood of usefulness of such an approach, especially when the instability of individual item statistics was considered.

The decision was made, then, to key the socially desirable response. For each of the 186 items the socially desirable response would be weighted +1 and the undesirable response zero; "undecideds" would be scored +1 or zero in such a manner as to dichotomize the distribution of responses to an item as close to the median as possible.

In order to identify the socially desirable response, copies of the inventory were mailed to 29 persons active in the field of highway safety, either in research or administratively. An accompanying form letter explained the nature of the study and requested opinions as to the socially desirable response. Eighteen of these experts responded in time to be included in the analysis. On the basis of the consensus of these experts, and the prior judgment of the investigator, nearly all of the items were keyed. Those few items which were not keyed in this manner were left to be keyed on the basis of the direction of their correlation with the clusters to which they belonged.

The Clusters

As indicated above, the purpose of setting up the 14 categories (or clusters) of attitude objects was to assure coverage of attitude areas of interest in this study, and to make possible a factor analysis of the items without having to actually compute and factorize the matrix of 186x185 inter-item correlation coefficients. Any such short-cutting of a factorization of inter-item correlations by means of factoring clusters and extending the analysis to the items makes the assumption that the factors that account for the inter-cluster correlations also account for the inter-item correlations (14, 38, 39); that is, there can be no more factors found among the items than are found among the clusters. It was strategic to have several more clusters than anticipated factors.

But in order to obtain meaningful cluster scores, the clusters had to be composed of items on which people would agree that those items properly belonged to the respective clusters. Accordingly, five research psychologists, colleagues of the investigator, were asked to sort the items (on cards) according to the list of categories in Table 1 with instructions to make additional categories if necessary.

No additional categories were made. Because it was desirable to have clusters whose meaning was very clear and stable, only those items on which at least five of six judges (including the investigator) agreed were actually assigned to a cluster to be scored with that cluster. Four clusters (5, 6, 12 and 13) came through this process with less than four items, and were thus dropped as clusters. (Further attrition occurred during the analysis when items beyond the .90 - .10 split were removed).

Collection of Data

As originally conceived, the purpose of this research was to study the dimensions of attitudes of general drivers in eastern urban U. S. Much thought was given to methods of obtaining a random sample of such population sufficiently large to justify factor analysis. Considerations of (a) the manipulability of responses to attitude items, and of criterion information, and (b) of the quantity of information desired (186 item responses and ten items of background and experience information - led to the decision to emphasize confidence in the data as obtained, at the cost of generalizability of results. Actually, the generalizability of the factor solution suffers much less than do estimations of population parameters from such accidental samples (33). The decision was made to use as subjects only those drivers who were known personally to the investigator or to a friend or relative of the investigator. It was felt that it would be possible in this way to minimize the threat felt by the subject that information given could be used to his disadvantage, and would thus result in information which would be minimally affected by deliberate manipulation, if not by vagaries of memory.

In the summer of 1955, 507 inventory forms were distributed directly to prospective subject drivers by either the investigator or a friend or relative of the investigator. Returns were made either directly by hand or by mail in self-addressed stamped envelopes. The percentage of completed returns was 64 percent: a total of 323 drivers participated, 254 men, 69 women. About ⅓ of the drivers were from the Camden-Philadelphia area and about ⅔ from the Washington, D. C. area.

Background Data on the Sample

The distributions of age, years driven, miles driven, moving violations for which fined, total accidents, and accidents for which at least partly responsible, are shown in Tables 2 - 7. A few comments on these data seem worthwhile. Modal age of the group (Table 2) is approximately 32; nearly 90 percent are between 25 and 55 years old. Years driven (Table 3) range from less than one year to more than 45, with the mode around 12. Miles driven (Table 4) vary from one thousand to 2. 5 million, and about 80 percent have at least 50,000 miles of experience. While 183 drivers report zero violations (Table 5), 95 report zero accidents (Table 6); there were 293 violations reported and 592 accidents - twice as many accidents as violations. Of the 592 accidents, at least partial responsibility is reported for 294 of them (Table 7), just about half.

Table 8 shows a distribution of respondents' occupations. The most numerous group are the "miscellaneous" with 123 drivers. Almost certainly the number of professionals (48 psychologists and 24 others) and general clerical (39) are disproportionately large for any other area save, perhaps, Washington, D. C.

Constitution of the Final Clusters

Before scoring the attitude clusters, frequency counts were made for each item for

TABLE 2

DISTRIBUTION OF AGE AS REPORTED BY 322 DRIVERS

Age in Years	f
65-69	1
60-64	8
55-59	8
50-54	12
45-49	26
40-44	44
35-39	63
30-34	83
25-29	55
20-24	17
17-19	5
	322
No data	1

TABLE 4

DISTRIBUTION OF MILES DRIVEN AS REPORTED BY 318 DRIVERS

Thousands of Miles	f
950-2, 500	7
900-949	0
850-899	1
800-849	0
750-799	4
700-749	1
650-699	1
600-649	3
550-599	0
500-549	11
450-499	2
400-449	3
350-399	6
300-349	16
250-299	19
200-249	37
150-199	32
100-149	55
50-99	55
00-49	65
	318
No data	5

TABLE 3

DISTRIBUTION OF YEARS DRIVEN AS REPORTED BY 323 DRIVERS

Years Driven	f
45-49	1
40-44	4
35-39	6
30-34	17
25-29	34
20-24	49
15-19	62
10-14	73
5-9	46
0-4	31
	323

TABLE 5

DISTRIBUTION OF MOVING VIOLATIONS FOR WHICH FINED, AS REPORTED BY 320 DRIVERS

Number of Violations	f
12	1
11	0
10	1
9	0
8	2
7	0
6	4
5	5
4	11
3	12
2	25
1	76
0	183
	320
No data	3

TABLE 6

DISTRIBUTION OF ACCIDENTS AS REPORTED BY 322 DRIVERS

Number of Accidents	f
10	3
9	0
8	7
7	0
6	10
5	10
4	18
3	42
2	61
1	76
0	95
	322
No data	1

TABLE 7

DISTRIBUTION OF ACCIDENTS FOR WHICH AT LEAST PARTLY RESPONSIBLE, AS REPORTED BY 321 DRIVERS

Accidents for which partly responsible	f
7	1
6	5
5	2
4	6
3	16
2	30
1	115
0	146
	321
No data	2

TABLE 8

DISTRIBUTION OF OCCUPATIONS OF 321 DRIVERS

Occupational Grouping	f
Psychologists	48
Other Professionals	24
Post Office Clerks, Carriers, Drivers	46
General Clerical	39
Police	12
Housewives	29
Miscellaneous	123
	321
No data	2

TABLE 9

CORRELATIONS AMONG BACKGROUND AND EXPERIENCE VARIABLES, MEANS AND STANDARD DEVIATIONS

(Decimals omitted)

Variable No.	Name	69[a] Women Drivers M	σ	1	2	3	4	5	246[b] Men Drivers M	σ	1	2	3	4	5
1	Age	34.97	9.03						36.39	9.24					
2	Years Driven	11.68	8.37	75					17.37	8.80	87				
3	Miles Driven	5.43	6.78	43	62				20.74	19.59	43	55			
4	Violations	.17	.64	05	09	36			1.14	1.75	17	21	36		
5	Accidents	.81	1.18	16	20	37	68		2.15	2.06	18	18	20	49	
6	Acc/Resp.	.51	.83	20	20	25	55	88	1.04	1.30	16	16	17	47	79

[a] For N = 69 an r = .24 is significant at .05 level

[b] For N = 246 an r = .13 is significant at .05 level

NOTE: For miles driven the means and sigmas are in units of 10,000 miles.

each response, agree, undecided, and disagree. For each item the "undecideds" were included with agree or disagree in order to dichotomize as close to the median as possible. Items with dichotomies beyond .90-.10 were removed; this left seven clusters for analysis, with one cluster having as few as four items. In five of these seven clusters it was possible to remove items with dichotomies beyond .85-.15. Since the other preliminary clusters either did not survive the judges' clustering, or had items with very little variance (very high p-values) they could presumably be ignored with little loss.

Relationships among Background and Experience Variables, Comparison of Means for Men and Women

For the complete-data cases, the intercorrelations among background and experience variables and the means and standard deviations are shown in Table 9 for men and women separately. In making comparisons between the groups, it must be cautioned that the women are for the most part a relatively low-mileage group. Of the 69 women, 41 reported less than 50,000 miles, but of the 246 men only 24 reported less than 50,000 miles. The mean of miles driven is nearly four times as great for the men.

TABLE 10

CORRELATIONS OF ATTITUDE CLUSTERS WITH BACKGROUND AND EXPERIENCE VARIABLES
(Decimals omitted)

Attitude Cluster	M	σ	Age	Years	Miles	Viol.	Acc.	Acc./Resp.
69 Women								
1. Speed	4.90	1.37	01	12	03	-28[a]	-17	-21
2. Others	9.00	3.24	05	05	-18	-14	-08	-08
3. Causes of Accidents	2.78	.88	-03	-02	-04	-11	03	05
4. Rules and Regulations	15.13	3.21	02	02	-08	-17	-10	-13
7. Cops	7.86	2.66	16	06	-11	-24[a]	-28[a]	-28[a]
9. G.D. Concept	4.84	1.06	11	-08	-12	-20	-12	-12
10. Vehicle	6.55	1.87	07	10	06	-18	-01	-03
246 Men								
1. Speed	4.35	1.75	10	06	09	-06	-03	-05
2. Others	9.20	3.03	06	06	11	02	10	09
3. Causes of Accidents	3.16	.81	-09	-08	02	12	12	15[a]
4. Rules and Regulations	14.02	3.93	13[a]	08	13[a]	-04	04	05
7. Cops	7.51	2.56	19[a]	12	04	-03	03	03
9. Good Driver Concept	4.81	.95	12	08	07	01	02	00
10. Vehicle	6.41	2.01	11	20[a]	26[a]	09	01	04

[a] Significant at .05 level

TABLE 11

CORRELATIONS OF ATTITUDE CLUSTERS WITH VIOLATIONS AND ACCIDENTS, MILES PARTIALLED OUT

Attitude Cluster	69 Women			246 Men		
	Violations	Accidents	Acc./Resp.	Violations	Accidents	Acc./Resp.
1. Speed	-31[a]	-20	-23	-10	-05	-07
2. Others	-08	-02	-03	-02	08	07
3. Causes	-11	05	04	12	11	15[a]
4. Rules and Regulations	-16	-08	-11	-09	02	03
7. Cops	-22	-26[a]	-27[a]	-04	02	03
9. Good Driver Concept	-16	-08	-10	-02	01	-02
10. Vehicle	-21	-03	-05	-01	-05	-01

[a] Significant at .05 level

TABLE 12

INTERCORRELATIONS AMONG ATTITUDE CLUSTERS

	69 Women						246 Men					
Cluster	1	2	3	4	7	9	1	2	3	4	7	9
1. Speed												
2. Others	23						15					
3. Causes of Accidents	07	22					11	17				
4. Rules and Regulations	16	42	30				50	31	15			
7. Cops	22	55	24	57			33	38	11	52		
9. Good Driver Concept	-04	-04	09	21	14		22	05	-04	35	14	
10. Vehicle	06	-16	-10	03	-04	39	09	-07	-05	23	06	21

TABLE 13

INTERCORRELATIONS[a], MEANS, STANDARD DEVIATIONS, AND K. R. -20's OF SEVEN ATTITUDE CLUSTERS N = 315 (Final Factor Residuals in Upper Half)

Cluster Number	Cluster Name	No. of Items	M	σ	K. R. -20	1	2	3	4	7	9	10
1	Speed	7	4.49	1.69	56	03	-01	-01	03	-01	00	-02
2	Other Users	16	9.13	3.09	67	16	02	01	-01	01	-02	01
3	Causes of Accidents	4	3.07	.84	16	07	19	02	-02	01	-02	02
4	Rules and Regulations	20	14.24	3.78	77	46	32	15	04	-01	03	-04
7	Cops	12	7.55	2.61	67	31	42	13	53	01	-01	01
9	Good Driver Concept	6	4.83	.97	13	17	03	-01	32	14	02	00
10	Vehicle	10	6.46	1.98	52	08	-09	-07	20	04	25	02

[a] Decimals omitted

TABLE 14

UNROTATED FACTOR MATRIX[a], F_0

Cluster Number	F_1	F_2	F_3	F_4	F_5	h_2
1	55	-19	33	18	-23	53
2	51	55	22	23	-12	68
3	19	21	08	11	22	14
4	82	-12	13	02	14	73
7	67	29	13	-32	-12	67
9	31	-26	-07	-05	09	18
10	28	-48	-42	-18	05	52

[a] Decimals omitted

TABLE 15

TRANSFORMATION MATRIX[a] Λ, CENTROID SOLUTION TO OBLIQUE SIMPLE STRUCTURE

	A	B	C	D	E
I	19	16	16	28	22
II	-40	39	24	-54	-01
III	29	-61	18	-77	19
IV	44	56	-90	-15	18
V	-73	-37	-28	-11	94

[a] Decimals omitted

Significance tests on the data of this study must be interpreted with caution since a) some of the variables have rather skewed distributions, b) the variables are correlated, so that the significance tests are not independent, and c) the universes of which these groups can be regarded as random samples cannot be stated with precision. It is of interest, rather than of prime importance to the purpose of this research, to examine the data for possible differences between men and women.

Mean age differs by only about one year for the men and women (not significant). Mean years driven is about five years greater for the men; men learned to drive at average age 19 while women delayed until about 23. On the average, the women drove about ¼ as many miles. In that experience their average number of violations is less than ⅙ as great, but the average number of accidents is more than ⅓ as great as men's; and the average number of accidents/responsible is just about ½ as great. That is, on the average, the women had a disproportionately low violation rate per mile and a disproportionately high accident rate per mile, compared with the men. All of these differences between means meet a test of significance beyond the .05 level.

As to the relationships among these variables (Table 9), age and years driven are highly correlated, and significantly more so for the men, .87 versus .75. Years driven and miles driven, are less highly correlated, .62 for women, .55 for men. Neither age nor years driven correlated more than .21 with number of violations, accidents, or accidents/responsible, in either group. Miles driven is generally more highly correlated with violations, accidents and accidents/responsible in the women's group than in the men's (but not significantly so). This is probably a reflection of the difference in phase of driving experience for the two groups. But these correlations are no higher than .37 in any case. The correlation of accidents with violations is significantly higher for women, .68 versus .49; caution must be used in interpreting these correlations, however, since many accidents involve violations, and the same event must often be included in both variables. The high correlation of accidents with accidents/responsible is large attributable to such part-whole relationship. One might expect violations to correlate more highly with accidents/responsible than with accidents, but this is not borne out in either group.

Attitude Cluster Score Means; Comparison of Men and Women

The means and standard deviations of attitude cluster scores are presented in the first two columns of figures in Table 10 for the men and women separately. On the Speed cluster and on the Rules and Regulations cluster the women's mean scores are significantly higher (.05 level). On the Causes of Accidents cluster, the men's mean score is significantly higher (.05 level). This latter difference will take on more meaning when relationships are considered below. None of the other mean differences is significant.

Relationships of Attitude Cluster Scores with Background and Experience Variables

The correlations of attitude cluster scores with background and experience variables are presented in Table 10, for the men and women separately. Interpretation of such relationships obtained in a cross-sectional study is beclouded by the peculiar nature of attitudes in that they can both influence and be influenced by experience. While one interpretation may appear more reasonable than another, the issue can hardly be settled without longitudinal studies.

For the women, the Speed cluster is significantly correlated with number of violations (r= -.28), the better (higher) the attitude score, the fewer the violations. Apparently, good attitudes toward speed may deter women from violations of speed laws. The Cops cluster is correlated with number of violations, accidents and accidents/responsible, (r's = -.24, -.28 and -.28 respectively), fewer violations and accidents being associated with better (higher) attitude scores. It would appear that women's experiences with cops by way of violations and accidents may promote undesirable attitudes toward cops.

For the men, attitude toward Rules and Regulations is somewhat correlated with age and with miles driven (each r = .13), better attitude scores being associated with greater age and more miles. Attitude toward Cops is also related to age (r = .19), older men having better attitudes. Attitude toward the vehicle itself is related to years and miles driven (r = .20 and .26 respectively) the better attitudes being associated with greater driving experience. Attitude toward causes of accidents is related to accidents/ responsible, and in the positive direction (r = .15), higher (better) attitude scores being associated with more accidents/responsible. Apparently, the very process of recognizing one's responsibility for his own accidents may promote desirable attitudes toward causes of accidents. It is equally possible that realistic attitudes toward accident causation lead to recognition of one's own responsibility for his own accidents. Herein may lie one possible approach to remedial action on the part of public safety agencies.

TABLE 16

CORRELATIONS[a] OF CLUSTERS WITH REFERENCE VECTORS

$V = F_0 \Lambda$

Cluster Number	F_1	F_2	F_3	F_4	F_5
1	53	00	00	00	00
2	01	60	00	-01	-01
3	-13	05	-07	-16	28
4	15	-04	07	18	35
7	00	00	52	00	00
9	06	-07	-01	28	13
10	01	-01	01	68	00

[a]Decimals omitted

TABLE 17

BETA WEIGHTS[a] OF CLUSTERS ON PRIMARY FACTORS

$A = VD^{-1}$

Cluster Name	No.	F_1	F_2	F_3	F_4	F_5
Speed	1	73	00	00	00	00
Others	2	01	82	01	-01	-01
Causes of Accidents	3	-18	06	-10	-17	48
Rules and Regulations	4	21	-05	11	19	60
Cops	7	00	00	81	00	01
Good Driver Concept	9	08	-10	-01	29	23
Vehicle	10	01	-02	01	71	01

[a]Decimals omitted

TABLE 18

INTERCORRELATIONS[a] AMONG PRIMARY FACTORS

$C_F = D(\Lambda'\Lambda)^{-1} D$

	F_1	F_2	F_3	F_4	F_5
F_1	1.00	28	54	10	66
F_2	28	1.00	61	-12	56
F_3	54	61	1.00	08	71
F_4	10	-12	08	1.00	16
F_5	66	56	71	16	1.00

[a]Decimals omitted

TABLE 19

TRANSFORMATION MATRIX $T = F_0 (F_0' F_0)^{-1} \Lambda D^{-1}$

(Transforms P matrix to A_I)

	A	B	C	D	E
1	2.45	.57	-.60	-.04	-1.59
2	.53	2.26	-1.03	.55	-.93
3	-1.51	-.61	-1.04	-.65	3.09
4	-.69	-.69	-.67	-.22	2.25
7	-.64	-1.03	2.95	-.18	-1.09
9	-.24	-.19	-.37	.29	.77
10	.02	.64	-.04	1.33	-.70

Since the effect of facade would be to enhance the size of all the relationships between attitude cluster scores and violations and/or accidents, there is little evidence of it here.

It is of some interest to note that the correlations with violations, accidents, and accidents/responsible are predominantly negative for the women, but predominantly positive for the men. When partial correlation coefficients were computed for these relationships, to remove the effect of differences in miles driven (Table 11), the signs did not change for the women, but, for the men, the correlations with violations were all negative but one. The magnitudes were not greatly affected however. (Regression of the respective variables on miles driven - the variable to be partialled out - could not be said to be assuredly linear or otherwise because of the degree to which the self-reports on mileage were so often grossly rounded).

It must be remembered that the correlations between the attitude measures on the one hand with violations and accidents on the other are considerably attenuated by unreliability, especially of the latter variables. In order to obtain some rough estimates of the unattenuated correlations, a value of .50 was used as a reliability estimate for violations and for accidents, and Kuder-Richardson -20 estimates were rounded upward for estimates of attitude cluster reliabilities. On this basis it would seem reasonable that the correlations for clusters three and nine should be about doubled, and the rest increased by about ½ to ⅔ in order to correct for unreliability in the measures.

TABLE 20

ITEMS USED TO INTERPRET FACTOR 1

No. of Item	Keyed Response	p	Beta Weight on F_1	
120[a]	D	72	1.49	Driving at high speed gives you a thrilling sense of power.
63[a]	A	75	1.36	Most drivers should not be allowed to go over 60 mph.
47[a]	A	49	1.09	The desire for speed is just like a disease.
52[a]	D	82	1.08	Speed limits are not needed in open country.
162	D	81	1.07	It's a thrill to beat other drivers at the getaway.
139	D	85	.90	It's a thrill to outwit other drivers.
85[a]	D	73	.87	If speed limits are reduced any, we might as well go back to the horse.
135	D	86	.82	It's fun to pass other cars on the highway even if you're not in any hurry.
22	D	45	.81	The increased horsepower in the new cars puts a new thrill in driving.
5	D	78	.77	It's fun to beat other drivers at the getaway.
114	D	79	.74	Unless a car has real pep and getaway there is no fun in driving it.
90	D	82	.68	It's fun to maneuver through traffic.
64	D	75	.63	Speed limits are not necessary for careful drivers.
145	A	78	.56	Driving in traffic is no fun.
54	D	68	.54	City speed limits are so low they are frustrating.

[a] Included in the Speed cluster

Relationships Among the Attitude Clusters

The intercorrelations among the attitude clusters are shown in Table 12, for the men and women separately. For only one relationship is there a significant difference (and that at the .01 level) between the two groups: Speed versus Rules and Regulations, r = .16 for women, .50 for the men. In both matrices the intercorrelations are generally rather low. It would seem, then, that the item-clustering was effective and that facade did not operate very strongly, or these values would be much higher.

For purposes of the factor analysis it seemed quite realistic to combine the two groups and use the intercorrelation matrix for all 315 cases. Women do constitute from ¼ to ⅓ of the driving population and we are seeking to identify the basic attitudinal dimensions.

Were there enough women, and large differences in intercorrelations, separate factorizations would have been warranted.

Procedure for Main Analysis

Since the primary objective of this study was a determination of the dimensions underlying drivers' attitudes, a factor analysis was the primary method. As indicated earlier, it would have been infeasible to obtain the 186x185 inter-item correlation matrix, to factorize it, and to rotate to simple structure, even if electronic equipment were available. By means of the clustering design described, the problem was reduced to a practicable size: the inter-cluster correlations could be factorized and the solution extended to all of the items. However, one usually sacrifices something by use of short-cut methods, and the risk taken here is that there are likely to be factors among the inter-item correlations which will not be detected among the inter-cluster correlations. If, however, the domain of interest was properly covered by the items, and the judges did a proper job of clustering, such undetected factors among the inter-item correlations should be of very minor nature. A similar point may be made with respect to any of the original clusters which did not survive as clusters: either their items have very little variance (i. e., people do not differ in their responses to them), or there is disagreement as to their items belonging together as a separate cluster. In either case it would seem that any factors which escape detection in this way are likely to be of lesser importance. There always remains the possibility, of course, that other investigators may be more ingenious in the writing of attitude items, and thereby isolate additional factors.

The most widely used and understood method for multiple factor analysis is, of course, Thurstone's centroid method (21, 33, 38, 39). Advantages of other methods, such as the mathematical elegance of Hotelling's principal components solution, were outweighed by either computational complexities or this first consideration.

The main analysis of this study was a factorization of the item responses by means of a centroid analysis on the inter-cluster correlations, rotation to oblique simple structure in the cluster space, then extension of this solution to the items by means of the method developed by Dwyer (14).

The formula for this extension is as follows:

$$A_I = P\,F_0\,(F_0{}'\,F_0)^{-1}\,\Lambda\,D^{-1}$$

where A_I = the matrix of beta weights on factors in predicting the items

P = the matrix of item-cluster correlations

F_0 = the original centroid solution on the inter-cluster correlations

Λ = the matrix which transforms F_0 to oblique simple structure

D^{-1} = the inverse of the diagonal matrix D, which in turn consists of the reciprocals of the square roots of the diagonal elements of $(\Lambda'\,\Lambda)^{-1}$

This extension of a factor solution to variables which are not included in the original factorization is a "least squares" fit (by row) and has the restriction that the final result yields weights on only those factors extracted in the original solution.

The sequence of steps for the full analysis was as follows (some of the steps are already reported in prior sections):

1. Obtain frequency counts for each item, for agree, undecided and disagree responses.
2. For each item, combine the undecided responses with either the agree or disagree responses in order to dichotomize as close to the median as possible; determine p-values.
3. Remove from clusters those items whose dichotomy is beyond .85 - .15. (For clusters three and nine, use items with dichtomies up to .90 - .10). Also remove those which are not keyed.
4. Score the clusters (+ 1 for socially desirable response, zero for undesirable response).
5. Obtain (tetrachoric) correlation of each cluster with each of the unkeyed items which belong to it and whose dichotomy is not beyond .85 - .15 (except for clusters three and nine).

6. Key the unkeyed items according to the direction of the correlation obtained in step 5, that is, assign a +1 to the response associated with high score on the cluster and zero to the response associated with low score on the cluster.
7. Include the keyed items from step 6 in the respective clusters and rescore the clusters.
8. Obtain Kuder-Richardson (Formula 20) estimates of the cluster reliabilities.
9. Compute intercorrelations of the clusters.
10. Obtain a centroid factor solution on the inter-r's from step 9.
11. Rotate the centroid factor solution to oblique simple structure.
12. Compute biserial correlations of each of the items (whether or not they are included in clusters) with each of the clusters.
13. Extend the rotated solution from step 11 to the items by using Dwyer's method and the biserials from step 12.
14. Interpret the factors - on the basis of the (beta) weights from step 13.

TABLE 21

ITEMS USED TO INTERPRET FACTOR 2

No. of Item	Keyed Response	p	Beta Weight on F_2	
51[a]	D	40	1.16	Large trucks should be kept off heavily travelled roads.
7[a]	D	67	1.09	Truck drivers often hog the road.
46[a]	D	53	1.04	It's easy for truck drivers to bully their way through traffic.
50[a]	D	45	1.00	Big slow trucks are real hazards on the road.
133[a]	D	41	.92	It gripes you to be bluffed by other drivers.
169[a]	D	81	.90	Small foreign cars are a nuisance on the highway.
56[a]	D	56	.89	Cab drivers are a very discourteous lot.
20[a]	D	53	.87	Bus drivers usually bully their way through traffic.
55[a]	D	59	.85	Taxi drivers break every rule in the book in order to make time.
178[a]	A	90	-.76	Hit and run drivers are just plain criminals.
2[a]	D	72	.58	Other drivers hardly let you be courteous.
118[a]	D	72	.57	It's hard to be careful if the other drivers aren't.
107[a]	D	49	.50	Pedestrians often just dare you to hit them.

[a] Included in the "other users" cluster

RESULTS AND DISCUSSION OF MAIN ANALYSIS

The Variables and Their Intercorrelations

The intercorrelations among the seven clusters, their means, standard deviations and K. R.-20 reliabilities for the 315 complete data cases are presented in Table 13, lower half (upper half contains residuals of factor solution). All the clusters except two have satisfactory reliability estimates, and those two are very low indeed: .16 and .13 for clusters three and nine respectively. Since K. R. -20's can be gross underestimates under conditions of more than one factor, these latter figures are regarded with caution. Cluster nine has a correlation of .32 with cluster four, which suggests that its true reliability is higher than .13. Cluster three has a small but

TABLE 22

ITEMS USED TO INTERPRET FACTOR 3

No. of Item	Keyed Response	p	Beta Weight on F_3	
123[a]	D	47	1.41	If traffic cops are nasty you lose respect for the law.
104[a]	A	81	1.29	Most traffic cops are fair minded people.
65[a]	D	76	1.27	After being bawled out by a cop a driver doesn't feel like obeying the law.
61[a]	D	71	1.27	Cops get a kick out of ordering drivers around.
66[a]	D	57	1.18	Police cars should be plainly marked in order to promote careful driving.
13[a]	D	58	1.16	Police cars that aren't marked are just rolling traps.
62[a]	D	77	1.12	It's hard to take orders from cops.
3[a]	D	61	.96	Bossy cops make you want to do the opposite of what they say.
150[a]	D	54	.93	A man ought to stick up for his rights when a cop tries to get tough with him.
39[a]	D	76	.91	Cops look the other way when taxi drivers break the rules.
6[a]	D	55	.89	You can talk your way out of a traffic ticket if you know how.
170	A	88	-.87	Any driver who disregards the rights of others on the highway is unfit to be licensed.
1[a]	D	41	.79	There's no use in arguing with a traffic cop; you don't have a chance.
83	D	89	.60	It must be fun to be a cop and order people around.

[a]Included in the "cops" cluster

significant correlation with accidents/responsible (Table 10). The decision was made to keep these variables in the factor analysis, although they would probably not influence the factor solution very strongly.

The Factor Solution

The centroid factorization was carried out using the KR-20 estimates in the diagonal as reliability estimates, since it was desired to factorize the reliable variance of the clusters, not just the common variance. In order to avoid negative diagonals in the residual matrices (due to underestimates of the reliabilities) use was made of the following formula to adjust the diagonal residuals when they threatened to turn negative on the next extraction:

$$r_{jk} = h_j h_k \cos \Phi_{jk}$$

When solving for h_j, $\cos \Phi_{jk}$ was taken to be 1, r_{jk} the highest residual for the variable in question, and h_k the diagonal entry of variable k.

Five factors were extracted; the centroid matrix and reproduced diagonal elements (h^2) are shown in Table 14, and the final residual matrix is shown above the diagonal in Table 13. Further extraction appeared quite unnecessary.

The transformation matrix Λ, which transforms the centroid solution F_0 to oblique

TABLE 23

ITEMS USED TO INTERPRET FACTOR 4

No. of Item	Keyed Response	p	Beta Weight on F_4	
129[a]	A	47	1.11	The condition of a man's car is a pretty good sign of the kind of man he is.
76[a]	A	44	1.03	A man hasn't much pride if he doesn't clean his car regularly.
77[a]	A	80	.96	Warming up the engine before driving is like being kind to a friend.
80[a]	A	75	.87	Treating the car with care is the mark of a good driver.
111[a]	A	69	.86	Unless the car is in A-1 condition it shouldn't be allowed on the highway.
53[a]	A	47	.83	Dirty windshields indicate sloppy drivers.
33[a]	A	58	.72	One of the greatest joys of modern life is the performance of a good car.
31[a]	A	65	.64	The most important gadgets on a car are the brakes.
100	A	96	.61	The least a man can do for safety's sake is have his car inspected regularly.
109	A	68	.61	The driver of the car is responsible for the behavior of his passengers.

[a] Included in the "vehicle" cluster

simple structure, is presented in Table 15. The result of this transformation, the V matrix, which consists of the correlations of the clusters with the oblique reference vectors, is presented in Table 16.

By post-multiplying the V matrix by D^{-1} (where D is the diagonal matrix consisting of the reciprocals of the square roots of the diagonal elements of $(\Lambda'\Lambda)^{-1}$), the A matrix is obtained, which consists of the beta-weights of the primary factors in predicting the clusters. The A matrix is presented in Table 17. The intercorrelations among the primary factors are presented in Table 18.

From Table 17 we may interpret the five factors in the cluster space. Factor one is identified with the Speed cluster, Factor two with the "Other Users of the Roadway" cluster, Factor three by attitude toward Cops, and Factor four is primarily identified by the Vehicle cluster. Factor five has sizeable weights on Causes of Accidents cluster and on Rules and Regulations cluster. It appears to be an appreciation of the need for rules and regulations in line with a recognition of the causes of accidents - an appreciation of hazard in driving.

Further insight into the nature of the five factors is furnished by their intercorrelations (Table 18). We see here that, (a) Factor four (Attitude toward the Vehicle) is nearly orthogonal to the other four factors, (b) Factor five is highly correlated with Factors one, two and three, and (c) Factor three is substantially correlated with Factors one and two.

Factors in the Item Space

The extension of this factor solution to the items was accomplished by the Method of Dwyer (14), applied to the matrix of item-cluster correlations. The transformation matrix $\overline{T} = F_0 (F_0' F_0)^{-1} \Lambda D^{-1}$ which was used to post-multiply the matrix of item-cluster

TABLE 24

ITEMS USED TO INTERPRET FACTOR 5

No. of Item	Keyed Response	p	Beta Weight on F_5	
37[a]	D	84	2.56	Automobile accidents are a matter of pure chance.
34[a]	D	50	2.46	Accidents are often caused by conditions beyond the control of the driver.
49[a]	A	87	2.31	Accidents are caused by somebody's mistakes.
158[a]	D	86	1.76	Accidents happen to only those drivers who are "accident prone."
59	D	98	1.54	Dipping your lights to oncoming cars is hardly worth the effort.
119	A	96	1.28	Not stopping for a fire engine or ambulance is keeping help from someone who needs it.
141	D	93	1.22	As long as no one gets hurt there's nothing wrong with breaking traffic laws.
71	D	93	1.21	Modern highways are so good you don't have to worry about conditions of the road when you drive.
176[a]	D	53	1.13	Fines don't stop anyone from breaking traffic laws.
110	D	93	1.05	There is no fun in driving if you have to obey all the rules.
96[a]	A	75	1.03	Anyone who doesn't drive by the rules should be kept off the highway.
41	D	89	.96	Risking your own life in a car is your own business.
173	A	66	.94	It's not reasonable to blame "conditions" for accidents since it's up to the driver to allow for them.
97	A	52	.91	Skill in handling a car is less important to safety than an an attitude of carefulness.
95[a]	D	72	.90	Many traffic laws are entirely unreasonable.
172[a]	D	59	.88	A driver should not be punished for breaking a law that he doesn't know about.
18	A	96	.86	Taking chances while driving is just asking for trouble.
106	D	90	.80	Most drivers who have accidents are just unlucky.
127[a]	D	63	.80	It is impossible to enforce traffic rules that most drivers don't like.
157[a]	D	55	.78	Some traffic laws are enforced too strongly.
17[a]	D	76	.78	It's foolish to signal for a turn when there is no traffic.
32[a]	D	83	.77	Strict traffic regulations are a great nuisance.
177[a]	D	81	.74	It is foolish to have to signal for a turn when there is no traffic.
143[a]	D	76	.70	Since so many people break the traffic laws there must be something wrong with the laws.
10	A	72	.70	Any driver who endangers others on the highway should be treated as a criminal.
102[a]	A	75	.68	Most speed limits are set by people who know what is best.
164	A	84	.65	Passing on hills or curves is just plain criminal.
185	D	88	.65	Traffic laws hold up the flow of traffic rather than help it.
174	A	83	.62	The driver who breaks the law should be held responsible for the accident.
4[a]	A	57	.61	If you don't signal in advance for turns or stops you shouldn't be licensed to drive.

[a] The first four items listed constitute the "Causes of Accidents" cluster; the other starred items are included in the "Rules and Regulations" cluster.

TABLE 25

CORRELATION OF COMPETITIVENESS-AGGRESSION CLUSTER WITH BACKGROUND AND EXPERIENCE VARIABLES

Variable	All Men N = 249-254	Men, 50,000 + Miles N = 227-229	69 Women
	r	r	r
Violations	-.13[a]	-.15[a]	-.21
Accidents	-.12	-.10	-.15
Accidents/Resp.	-.14[a]	-.14[a]	-.17
Age	.13[a]		-.06
Years Driven	.06		.02
Miles Driven	.09		-.01

[a]Significant at .05 level

correlations in order to obtain the beta weights of the items on the factors is shown in Table 19. This extension is a least-squares solution and yields beta weights on factors extracted in the original solution. This makes possible an interpretation of the factors in the item space, and to the extent to which the factors in the item space are covered by the factors in the cluster space, we have, in effect, factorized the inter-item correlations.

In order to interpret a given factor in the item space the following criteria were used to select the items for this purpose:

1. The beta weight on this factor had to be at least .50.
2. This beta weight had to be the highest one for this item.
3. The next lower beta weight for this item must not be larger than half this highest one.

Table 20 presents the critical items for Factor one along with the keyed responses, p-values, and beta weights. Five of the items included in the original speed cluster have beta weights among the highest. It must be cautioned that the rotation carried out in the cluster space made the speed cluster identical with the speed factor, and items which are a part of the speed cluster would be expected to have somewhat inflated item-cluster correlations, and hence inflated beta weights on this factor. The same caution holds for Factors two, three and four, but to a lesser extent for Factor five, because it was rotated with regard to two clusters (Rules and Regulations and Causes of Accidents).

Examination of the items in Table 20 reveals that the common element is not just speed, but competitive speed. Apparently the pre-motor-vehicle spirit characterized by the challenge, "My horse can beat your horse!" is still with us.

Table 21 presents the critical items for Factor two. All of these items are included in the "Others" cluster. This factor seems properly characterized by attitude toward other users of the roadway.

Table 22 presents the critical items for Factor three. Only two of these items were not in the original "Cops" cluster. This is clearly characterized by attitude toward cops.

Table 23 presents the critical items for Factor four. This is clearly the attitude toward the Vehicle itself.

Table 24 presents the critical items for Factor five. This one is not so readily interpreted. It will be remembered that this factor correlates quite highly with all the others except Factor four (Vehicle). Many more items meet the criterion for inclusion here than for the other four factors. The extremely high beta weights for the first four items listed must be regarded with caution since they do in fact constitute the whole of the "Causes of Accidents" cluster. Also, several of the items have very high p-values, beyond .90!

To be sure, attitude toward rules and regulations - or conformity to the law - is represented here, as is also the notion of causality of accidents and the notion of responsibility. It is not unreasonable that these should all be closely akin, and should correlate with attitudes toward speed, others, and police. An underlying appreciation of the need for regulation, an awareness of the hazards in driving, or just plain care or concern for safety, would seem to characterize this factor. Perhaps further research might well show two or three factors here, but it does not emerge as a very distinct factor in this study.

Because of the mixed findings for the relationships between the attitude clusters and violations and accidents, the factor solution was not extended to these variables.

SUMMARY AND CONCLUSIONS

The primary purpose of the study was to determine the dimensions, or factors, underlying drivers' attitudes. Four factors were hypothesized: (a) Appreciation of hazard, (b) Social responsibility or conformity, (c) Attitude toward the vehicle itself, and (d) Attitude toward speed.

A 186-item attitude inventory was developed to measure the 14 aspects of drivers' attitudes considered to cover the domain. This inventory was administered to 323 general drivers from the Philadelphia and Washington, D. C. areas. After eliminating items with extreme p-values and items on which judges' agreement as to the cluster to which the item belonged was less than five out of six, seven clusters remained for analysis.

A short-cut factor analysis of the items was achieved by factorizing the inter-cluster correlations and extending this solution to all of the items by means of the method developed by Dwyer. Five factors were identified: (a) Attitude toward competitive speed, (b) Attitude toward other users of the roadway, (c) Attitude toward cops, (d) Attitude toward the vehicle, and (e) A general attitude of care or concern for safety. Factors one, two and three are substantially correlated. Factor four (Vehicle) is nearly orthogonal to the others, while Factor five is highly correlated with Factors one, two, and three. Hypothesized factors one and two seem in this analysis to be imbedded in a more general factor of carefulness.

Attitude cluster scores were correlated with background and experience variables for 69 women and 246 men separately. For the women, attitude toward Speed was significantly correlated (-. 28) with number of violations, better attitude scores being associated with fewer violations. Attitude toward Cops was also correlated with number of violations, accidents and accidents/responsible (-. 24, -. 28 and -. 28 respectively), better attitude scores being associated with fewer violations, fewer accidents, etc. Apparently good attitudes toward speed may deter women from violating speed laws, and women's experiences with cops by way of violations and accidents may promote unfavorable attitudes toward cops.

For the men, attitude toward Causes of Accidents was significantly correlated with Accidents/Responsible (+. 15). Apparently the process of recognizing one's responsibility for his own accidents may promote favorable attitudes toward causes of accidents (or, having favorable attitudes toward causes of accidents facilitates recognition of one's responsibility for his accidents). Attitude toward Rules and Regulations was significantly correlated with age (+. 13) and with miles driven (+. 13), better attitudes being associated with greater age and experience. Attitude toward Cops was correlated with age (+. 19), older men have better attitudes. Attitude toward the vehicle was correlated with years driven (+. 20) and miles driven (+. 26) better attitudes being associated with greater experience.

Women's mean scores were significantly higher than men's on attitude toward Speed and attitude toward Rules and Regulations. The men's mean score was significantly higher on Causes of Accidents cluster.

On the average, the women had driven about ¼ as many miles as the men in ⅔ as many years. On the average, the women had ⅙ as many violations, ⅓ as many accidents and ½ as many accidents/responsible. That is, the women had a disproportionately low violation rate per mile, but a disproportionately high accident rate per mile. The ratio of violations to accidents was about 1:2 for the men, but about 1:5 for the women.

Further Analysis on Driver Aggression

When the items in Table 20 were examined for the purpose of interpreting Factor 1, certain of the items appeared clearly to be measuring an attitude of competitiveness, or aggression. And this led to the interpretation of this factor as competitive speed, rather than just speed. Subsequently, these six items (numbered 5, 90, 135, 139, 145 and 162) were scored as an additional cluster, and correlated with background and experience variables. The results are shown in Table 25.

Within the limits of the measures and samples used, it appears that competitiveness, or aggression, is related to violations and accidents for which responsible, at least for the men; greater aggression is associated with more violations and accidents/responsible. Also, as would be expected, this measure is related to age, younger men being more aggressive.

For the women, none of the correlations with violations or accidents is significant, very probably because there are too few cases to detect small relationships. The signs of these correlations, however, are all in the expected direction, and the smallest is always with total accidents, probably because raw number of accidents has lowest reliability. Very interestingly, there seems to be no relationship of age with aggression for the women.

That Years Driven and Miles Driven are not related to this measure of aggression suggests that it is not affected by driving experience, but only (for the men at least) by maturation.

This appears to be an area worthy of attention by researchers, educators, and administrators who are interested in highway safety, particularly when we consider the role of competition in the way of life of the Western world.

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Development of a Driving Attitude Scale

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Driving attitudes often may become influential factors leading to the occurrence of traffic violations and accidents. However, a great proportion of reported work in this field consists of expert opinion; only two scales which purport to measure driving attitudes have been published and research does not indicate them to be wholly satisfactory.

During the last five years, development of a driving attitude scale has been in progress in the Institute of Transportation and Traffic Engineering of the University of California. To obtain descriptions of real traffic situations for this scale, two clinical psychologists conducted informal interviews with 300 habitual traffic violators. During each interview, the violator described the manner in which he had received recent traffic citations and expressed himself freely regarding the actions of other drivers and police officers in those traffic situations. From the complete set of descriptions, the interviewers formulated 100 multiple-choice items to represent fairly typical traffic situations experienced by most drivers. Multiple-choice items, permitting more than a simple choice between accepting or rejecting a proposition contained in a complete sentence statement, presumably will (a) cover a wider range of attitude toward certain situations, permitting greater potential differentiation between criterion groups of drivers, and (b) make it more difficult for individuals to endorse the response which is believed to be more socially acceptable as a driving attitude.

Fifty-five items of the original group are now undergoing preliminary validation. Test results have been obtained from a large number of university students, and the testing of traffic violators is proceeding slowly. For certain items, the results from the students show statistically significant differences between groups of individuals as classified in terms of traffic citations received while driving in California. Certain items also differentiate between groups of individuals as classified in terms of their reported highway driving speeds under different conditions. Other data tend to support these findings. For the significant items, comparisons of relative response frequencies indicate considerable agreement with some psychological expectations.

● FOR SEVERAL YEARS, psychologists and other social scientists have been interested in the nature of attitudes and their influence on human behavior. Most psychologists seem to regard an attitude as a tendency to act in a certain way toward some object or situation in the environment (7). Although research in driving attitudes has been conducted for about 20 years, most reported work in this field consists of expert opinion. Only two scales which purport to measure driving attitudes have been published, the Siebrecht Attitude Scale and the Conover Driver Attitude Inventory. Research has shown these scales to be unsatisfactory as attitude measures (1, 3, 8).

Methods of measuring attitudes in psychological studies have been classified as direct and indirect. Methods which make no attempt to conceal the purpose of the scale have been called direct methods. The scales published by Siebrecht and Conover illustrate this approach. Methods which try to conceal the real intent of the scale have been called indirect methods. Using this approach, measurements of attitudes are inferred from responses to items of the scale. The attitude items to be considered in this paper illustrated one indirect technique.

DESCRIPTION OF SCALE

During the last five years, research in developing a driving attitude scale has been in progress in the Institute of Transportation and Traffic Engineering of the University of California. The items which have been constructed and tested for this scale may be characterized by three unique features, which are the following:

Items Represent Actual Traffic Situations

The items for the attitude scale represent actual rather than imaginary traffic situations. To obtain descriptions of real traffic situations and driving experiences, two clinical psychologists conducted informal but carefully structured interviews with 300 habitual traffic violators in Los Angeles, defined legally as "negligent operators" by the Vehicle Code of California (5). During the interview, the violator was asked to recall his previous traffic citations and to describe as clearly as possible the circumstances which led to them. He was encouraged to express himself freely during the interview. Previous papers have described the results of the interviews (2, 4, 9). Using the descriptions of these traffic situations, the interviewers prepared 100 attitude items.

Items Were Prepared in Multiple Choice Form

These items were prepared as multiple choice items with four alternatives. Items of this type were believed to sample a wider range of attitudes than, for example, true-false items. The process of writing the attitude items from the descriptions of traffic situations is illustrated in Appendix A.

In the present form of the questionnaire, the subject is instructed to endorse the one alternative action which most closely reflects his own driving behavior in the kind of situation described. He is told that what he considers to be the "best," "right," or "safest" thing to do is not important in the test situation. It is assumed that individuals will endorse those actions which reflect a priori their underlying attitudes.

Trial Response Keys Have Been Based on Experimental Findings

In this approach, the methods of selecting items for tentative response keys have been based thus far on experimental test results. This approach differs in principle from those which use a priori considerations of the investigator or judges for these procedures. Several empirical methods have been used thus far in selecting some of the attitude items and alternatives for differentiating between specific groups of drivers. The purpose of this study was to describe one method which differentiates to a considerable degree between two groups of individuals classified by their reported driving speeds.

METHOD

During 1955-56, test results were obtained from two large groups of students at the University of California, Los Angeles. These two groups, to be called Group A and Group B, contained 130 and 145 individuals, respectively. Group B was used as a cross validation sample for Group A. The two samples were reasonably similar in such factors as age level, sex, and reported length of driving experience in California.

All subjects in both groups were given a questionnaire of attitude items. Group A received a form containing the 100 multiple choice items, while Group B completed a reduced form (which is presently called the Driving Survey) containing 55 of the 100 items in their original order. In addition, each group completed an inventory consisting of items about one's personal driving habits and experiences. Four items concerning driving speed from this inventory were used for classifying the subjects of Group A in terms of speed. One of these items was the following:

What is your usual highway driving speed (MPH) during daylight?

20 30 40 50 60 70 80 90

The subjects were instructed to indicate their responses on a continuum similar to those used in numerical rating scales. For IBM procedures, all responses were evaluated to the nearest five mph and recorded in IBM cards.

The 130 subjects in Group A were classified in terms of driving speed by use of a simple summation of the numerical values on the four speed items in the inventory. These sums were ranked in order. Then, using the median of this distribution, the subjects were divided into two subgroups which were called the "slow" drivers and the "fast" drivers. This procedure gave 67 slow and 63 fast drivers.

The classification of the 130 subjects into these two speed groups seemed to be justified. Some examination of their official traffic records for driving in California showed that the fast drivers as a group differed significantly from the slow drivers in three major areas of traffic citations.

Using IBM procedures, the response frequencies for the 67 slow and 63 fast drivers in Group A were obtained for the 55 attitude items common to Groups A and B. Assuming random sampling from a common population, the response frequencies of the slow and the fast drivers for each alternative of each item were tested for independence of this speed classification using chi square (X^2). Chi square was considered significant when its chance probability, by reference to statistical tables, was not greater than .05.

Certain item alternatives with significant chi squares were selected for response keys. Ten items with alternatives which were endorsed to a greater degree by the fast drivers were selected for a fast key, while 10 items with choices endorsed to a greater extent by the slow drivers were used as a slow key. Five items were common to these two response keys. A combination fast-slow key was composed of all the item alternatives from the two separate keys. Using this key, a subject's score was the algebraic sum of his score on the fast key (scored plus) and his score on the slow key (scored minus).

Predictions of how the individuals would be classified in Group B, the cross validation sample, were made using these three response keys. With the slow response key, it was predicted that the subjects in Group B with scores above the median of their own distribution would be classified as the slow drivers. Using the fast response key and the combination of the two keys, it was predicted that the subjects with scores higher than the median of their own distribution would be classified as fast drivers. Then, the subjects in Group B were classified as fast or slow drivers in terms of the median of their own distribution of speed values using the identical procedure of the original sample.

RESULTS

Significance of Response Keys

The chi squares for all three response keys were significant beyond the .01 level. This is evidence of a lack of independence between the speed classification method and the technique of scoring the responses to the attitude items. To state this finding in positive terms, using responses to certain attitude items, it was possible to separate the slow from the fast drivers in the cross validation sample (based on their own reported driving speeds) with greater accuracy than one could obtain by chance. The chi squares and percentages of correct individual predictions are shown in Table 1.

Table 1 shows that the three response keys predicted the actual speed classification of subjects about equally well. On the average, the predictions were correct for about 66 percent of the 145 subjects in Group B. Table 1 shows that the combination fast-slow key using all 20 alternatives (15 different items, since five items contributed to both the slow and the fast keys) did not improve the accuracy of prediction sufficiently to warrant further use in this context.

Some examination of the score distributions for the three response keys suggested that the percentage of correct predictions might be much higher for subjects near either extreme of the continuum of speed values. To explore this possibility, the number of

TABLE 1

STATISTICS FOR THREE RESPONSE KEYS USING TOTAL SAMPLE
(N = 145)

Response Key	Number of Item Alternatives	Chi Square	Percentage Correct Predictions
Slow	10	9.37[a]	63
Fast	10	17.99[a]	68
Fast-Slow	20	20.02[a]	68

[a] Significant at the .01 level.

TABLE 2

STATISTICS FOR THREE RESPONSE KEYS USING UPPER AND LOWER 25 PERCENT OF TOTAL SAMPLE
(N = 73)

Response Key	Number of Item Alternatives	Chi Square	Percentage Correct Predictions
Slow	10	13.77[a]	71
Fast	10	16.98[a]	74
Fast-Slow	20	14.97[a]	73

[a] Significant at the .01 level.

correct predictions was determined for the subjects in the upper and lower 25percent of the distribution of speed values for Group B. One might consider these individuals to tend toward more extreme driving speeds (either fast or slow) than the subjects nearer the median of the distribution. The results based on the upper and lower 25 percent of the subjects are shown in Table 2.

Table 2 shows that the percentage of correct predictions was higher for the subjects in the two extreme groups than for the entire sample. The three keys again predicted the actual speed classifications about equally well.

Content of Significant Items

In addition to the statistical significance of these results, the content of the items contributing to the response keys seemed to be largely consistent with previous psychological expectations about fast vs. slow driving behavior. While the items themselves represented several kinds of traffic situations in addition to speed situations, the traffic behavior expressed by the item alternatives in the response keys was consistent, in most instances, with fast or slow driving. The alternatives in the fast key mentioned behavior that would enable a driver to reach his destination with a minimum of delay or inconvenience. The responses in the slow key suggested passive behavior—an acceptance of the traffic situation in which drivers found themselves.

SUMMARY

This paper has described briefly the development of a driving attitude scale (which is presently called the Driving Survey) in the Institute of Transportation and Traffic Engineering of the University of California. This scale consists of 55 multiple choice items based on descriptions of actual traffic situations. From this scale, certain item alternatives which differentiated between two criterion groups of drivers (Fast and Slow) in one sample of university students were incorporated into three subtests. Using these three subtests, or response keys, predictions of speed classification as fast or slow were made for an independent cross validation sample of subjects. These predictions

were correct, on the average, for about 66 percent of the cross validation group. The traffic behavior expressed by the item alternatives in the response keys was consistent, in most instances, with fast or slow driving. The predictive value of these subtests might be improved by the use of additional items in the Driving Survey. Further research may enable us to describe driving attitudes which seem to be characteristic of other criterion groups.

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Appendix A

The process of writing the 100 attitude items from the complete set of descriptions may be illustrated as follows:

One kind of traffic situation described by several violators involved driving on a city street where the traffic signals were timed at a faster speed than the posted speed limit. Should a driver obey the legal speed limit, which may tend to create congestion? Or should he try to drive with the timing of the traffic signals, which means that he must exceed the legal speed limit? Some drivers experience this type of situation every day. One violator described his experience in the following way:

> "It is funny that the lights are not synchronized with the indicated speed. If you drive 35 mph on National, you do not make the lights. In order to make the lights, you have to speed up. I know the street very well because I travel the same route every day. I know exactly where and when to step on it. So this time he (police officer) caught me." From a descrip-

tion of this kind of traffic situation, a multiple choice item was formulated as follows:

You are driving to work in a 25 mph zone. Signs read that signals are set for 30 mph. It has been your experience that you must drive much faster than 30 mph to make them. What do you do?

A. Drive within the speed limit of 25 mph, even though you may miss some of the signals.
B. Drive fast enough to make the signals smoothly, even though you must exceed the speed limit.
C. Try to stay ahead of traffic; otherwise you may miss certain signals.
D. Try to move along with traffic whether you make the signals or miss them.

This item involves the essential feature of the traffic situation as described - the necessity of exceeding the legal speed limit for driving with the traffic signals. The four alternative choices per item, stating real courses of action which the violator as the driver might have followed or did follow in part, were also suggested by the descriptions.

Five of the 100 items which mention other kinds of traffic situations are the following:

You are driving on a paved country road where the speed limit is 25 mph. Traffic is light. How fast do you drive?

A. 25 mph
B. 30 mph
C. 35 mph
D. 40 mph

You are slowly approaching a blind intersection. Two cars on the other street, one on your left and one on your right, reach the intersection when you do. What do you do?

A. Stop quickly; then see what the other two drivers will do.
B. Stop and wait until the car on your right has crossed the intersection; then proceed.
C. Continue slowly toward the intersection until you see whether the other two drivers will stop.
D. Stop and wait until the other two cars have crossed the intersection; then proceed.

As you approach an intersection for a left turn, a car on your right stops for a pedestrian who is crossing your street from right to left. As the pedestrian reaches your lane, he sees you, stops, and gives you a sign to proceed. A motorcycle police officer is watching traffic. What do you do?

A. Give the pedestrian a return sign to proceed.
B. Let the pedestrian know that you see his sign; then turn.
C. Stop and wait for the pedestrian to reach the curb before you turn.
D. Stop and wait for the pedestrian to cross your lane; then turn.

You are driving in a 35 mph zone. As you come to within about three car lengths of an intersection, the traffic signal changes to yellow. What do you do?

A. Speed up slightly and continue through the intersection.
B. Slow down and prepare to stop at the intersection if necessary.
C. Maintain your speed; you feel that you can make it in time.
D. Try to stop immediately; you feel that you cannot make it in time.

You are waiting in an intersection during the evening rush hour when the traffic signal changes to red. Traffic on the other street is beginning to move. A motorcycle officer is watching traffic. What do you do?

A. Try to back up slowly to the crosswalk behind you.
B. Wait in the intersection for the officer to direct you through traffic.
C. Tap your horn and proceed slowly through the intersection.
D. Proceed through the intersection as soon as traffic will permit.

The 100 attitude items, which represent several fairly typical traffic situations, will be subjected to further tests in differentiating specific groups of drivers who may experience these situations.

Community Study of the Characteristics of Drivers and Driver Behavior Related to Accident Experience

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This is a study of human characteristics and driver habits considered to be associated with motor vehicle accidents. The basic sample of Schenectady, N. Y. was established by visiting 1, 567 households in that city during 1955. Of these, 810 were driver or interview households and the remaining 757 were no-interview households.

This study was conducted by the New York State Department of Public Works in cooperation with the Bureau of Public Roads. The New York State Department of Health collaborated in the study in the planning and interpretation of data phases.

For the collection of data, 526 male and 284 female drivers were interviewed using a schedule of 60 questions relating to personal, social, health and driving characteristics, including miles driven for a 2½-year period from January 1953 through June 1955. Accident records for the respondents covering this 2½-year period were searched from the files of the Motor Vehicle Bureau and evaluated by a panel of judges to determine accident responsibility.

Data for each characteristic collected in the interview were tabulated by three groups of exposure—low, medium, and high—and each related to the drivers' accident status—no-accident, accident responsible, and accident not responsible—for the range of answers obtained.

The general hypothesis of the whole study is that drivers responsible for motor vehicle accidents have different personal, social, and driving characteristics than drivers who have not had accidents. Each characteristic of the respondent was put into the form of a specific null hypothesis and tested statistically.

To determine those attributes that may be causally associated with driver behavior, a factor test was applied to those variables for both male and female drivers that (a) were statistically significant on a 95 percent level, (b) were selected on a statistical judgment basis, and (c) were selected because of current interest in the variable.

To test the hypothesis that there is no difference between accident and no-accident drivers in the way they drive, 428 male and 122 female drivers were followed while driving in Schenectady and their driver behavior was noted and rated on a scale to include speed, headway, lane markings, passing, traffic signals, stop signs, turning movements, yielding, and attentiveness. A scoring system was adopted to group the drivers according to their rated driver behavior into categories of unsafe, predominately unsafe, neutral, predominately safe, and safe drivers. Accident records of the observed drivers for a 2½-year period, January 1953 through June 30, 1955, were searched and the data were tabulated by sex to show the relation between the five categories of drivers by the no-accident and accident drivers. The types of accidents were likewise grouped for examination. Composition of the sample, characteristics of drivers and cars driven with accident experience are also examined.

●THE RISK OF an automobile accident is accepted by most people as a part of their lives. Actually little serious thought is given to the hazards of automobile travel, perhaps because accidents have become a part of the present system of values.

In spite of the public's generally casual attitude toward this potential danger, the cost to society is such as to cause real concern among both governmental and private groups. One of the newest needs recognized is a scientific study of the drivers themselves. It was on this very note, in fact, that Dr. Detlev W. Bronk, President of the National Academy of Sciences, opened the 34th annual meeting of the Highway Research Board. Although the principles and methodology for this type of research are known by students of human behavior, the project reported here is virtually the first instance in which they have been utilized to examine the phenomena of driving and accidents.

This study was conducted in Schenectady, N.Y., by the New York State Department of Public Works in cooperation with the United States Bureau of Public Roads. The New York State Department of Health collaborated in planning the project and in the preliminary interpretation of the data.

The ground work for this research was based on a combination of data from three pilot studies and the knowledge of traffic engineers, social scientists, and epidemiologists. As a research project, it is unique in at least four respects. First, it is different because of its interdepartmental and interdisciplinary approach. Second, it is one of the first studies of accidents to go beyond a clinical examination of the drivers involved. It is based on a random sampling of all drivers in a community to determine whether drivers involved in accidents have different characteristics from those who have not been in accidents. Third, methods were developed and used for assessing the responsibility for accidents and for obtaining the number of miles driven. This was defined as "exposure." Fourth, drivers were rated on their driving in terms of safe-unsafe behavior while they drove without knowing that they were being followed.

The findings reported are those considered to be most useful. Many more studies should be made of automobile drivers, their accident records, and other related factors. Data from such sources will build the store of knowledge necessary for a planning program of automobile accident prevention.

PART I. FIRST PHASE
Determination of Data

General

Research in driver behavior and highway safety in the Schenectady project was handled in two phases. The principal phase was interviewing drivers in their homes. The second phase was observing motorists as they drove on the streets.

The primary purpose of each phase was to compare those drivers who had been involved in accidents with those who had not had accidents.

Fundamental to this endeavor were three earlier pilot studies on accidents, certain relevant literature, and the abilities of the members of the Interdepartmental Committee representing different disciplines and research experience.

Background

Prior to beginning the work in Schenectady, studies had been made in West Sand Lake (1), Oneonta (2), and Saratoga Springs (3), each in New York State, which demonstrated the feasibility of conducting research on a community basis using the interview and observation methods.

In the literature, there was no record of a study of motor vehicle accidents based on the community research method. According to Ross A. McFarland (4), who has compiled an extensive review of the literature on accidents, the range of work has been "from opinion essays to critical theoretical discussions, from a simple counting of accidents to complex statistical analyses, and from everyday observation to controlled experiment."

The Committee set up the following criteria for selecting the community to be studied:

1. Where accidents are recorded.
2. Where accidents are investigated.
3. Where the accident rate is normal or average.

4. Where the community is reasonably isolated.
5. Where there is a usual amount of through traffic.
6. Where there is a diversity of industries.
7. Where there are few suburbs.
8. Where there is a population over 25,000.
9. Where there is a well-balanced traffic pattern.
10. A location easily accessible to Albany.

It was found that Schenectady fulfilled most of these requirements. In addition, the study was welcomed by the city officials.

INTERVIEWS WITH A SAMPLE OF DRIVERS

The Research Design

The Interdepartmental Committee met and determined the scope of the work, the definitions of terms and the procedures for finishing the work within a year. A statement incorporating their point of view, basic assumptions, dimensions of the project, and hypotheses to be tested were set forth in a research statement.

In their planning, the Committee made use of results from the Oneonta, Saratoga Springs and West Sand Lake pilot studies, as well as interviews with some West Sand Lake respondents. These data helped in defining "accident" as "a motor vehicle mishap occurring between January 1, 1953 and July 1, 1955 on file with the New York State Bureau of Motor Vehicles."

Another operational definition was "a driver is anyone 16 years of age or over who has operated a motor vehicle at any time from January 1, 1953 to the date of the interview."

Construction and Pretest of the Interview Schedule

Once the areas of investigation, hypotheses, definitions, and instruments were decided upon, questions were devised to secure the type of information desired. The questions (Appendix B) were formulated to test a specific hypothesis, to secure control data, and in a few instances, to provide a setting against which facts could be remembered. If no driver was present or if a driver was not to be interviewed in the household visited, the interview was terminated after asking the questions on the first two pages.

When drivers were interviewed, they were asked about the amount of time they spent motoring within the last three years and the mileages traveled in order to get their average monthly mileage. These questions were the first of seven separate sets of questions designed to learn how far people drove within a given period. The number of miles for such a time period was defined as the "exposure" of the driver.

The difficult questions of (a) present car speedometer readings, (b) past car speedometer readings, (c) 1955 mileage, (d) sample day driving, (e) 1954 estimation of mileage, (f) 1954 calculation of trips, and (g) 1953 estimation of mileage, were asked during the first half hour. The driver was then the freshest and the most interested in the difficult work of recalling the facts. Once the mileage data were secured, the hard part of the interview was finished.

Once the schedule of questions was drafted and revised, a test of the wording and their sequence was made in actual interviews in order to retain material that worked best and discard all that did not contribute to the results. It was thought best not to confuse the work areas in Schenectady by any preliminary interviewing. Permission was therefore secured from the Mayor and Police Chief in the adjoining village of Scotia for conducting certain interviews there. Blocks and households were selected just as they would later be selected in Schenectady. In addition, to provide an opportunity to examine the schedule, this pretesting procedure enabled some interviewers to receive initial training. Results were tabulated and scrutinized before decisions were made as to what was feasible to include and what should be added for clarity and for securing information by which hypotheses could be tested. The questions included in the interview schedule, according to general areas, are shown in Table 1.

TABLE 1

THE QUESTIONS BY GENERAL AREAS INCLUDED IN THE INTERVIEW SCHEDULE
(Schenectady Interview)

1. General Characteristics of Drivers

   a. Sex
   b. Age
   c. Education
   d. Marital status
   e. Labor force
   f. Weight

2. Exposure

   a. Annual mileage for:
      1 - 1953-using a combination of speedometer readings and estimated mileages.
      2 - 1954-using a combination of speedometer readings, estimated and calculated mileages.
      3 - 1955-6 months-using a combination of calculated and mileages recorded by diary.

3. Driving Experience

   a. Years of driving experience
   b. Motor vehicle accidents January 1, 1953 to June 30, 1955 by type and accident responsibility

4. Speed

   a. Speed on the open road
   b. Opinion of whether a slow or fast driver
   c. Fastest ever driven on the open highway

5. Skill

   a. Opinion of own driving skill
   b. Driving instructor
   c. Number of times driver exam taken

6. Safety-mindedness

   a. What is done to wake up when sleepy at the wheel
   b. Whether or not they drive after drinking on occasion

7. Attitude on Traffic Regulations

   a Enforcement of traffic laws
   b. Belief about stop signs being generally observed
   c Opinion on necessity of drivers coming to a full stop at a corner stop sign

8. Medical Aspects

   a. Use of alcohol
   b. Use of tobacco
      1 - smoke now
      2 - how much
      3 - smoke while driving
   c. State of health
      (hayfever, asthma, diabetes, high blood pressure, stomach ulcer, arthritis, rheumatism or neuritis, limited use of either arm or leg, fainting spells or epilepsy, nervous or emotional illness, chronic condition or long drawn-out illness, and trouble hearing).

9. Social Stress
   a. Share of worries the last three years

Table 1 (continued)

b. Use of driving to relieve tension
c. Affect on driving when angry
d. Affect on driving when sad or depressed
e. Relative nervousness
f. Trouble getting to sleep
g. Enjoy driving
h. How they feel when they drive

10. Social Characteristics

a. Type of dwelling
b. Type of neighborhood
c. Economic level
d. Number of people in household
e. Occupation

11. General Opinions

a. Whether or not they think other drivers are courteous
b. Opinion of night driving
c. Opinion about the size of route signs
d. Opinion of other peoples driving according to the way they feel

12. Other Characteristics

a. Wearing of glasses
b. Use of sunglasses while driving
c. Year of car driven most
d. Make of car driven most
e. Car breakdowns
f. Relative ease of finding their way on a strange road
g. Whether or not satisfied with appearance of car they drive
h. Satisfaction with mechanical performance and the way their car drives

Some 200 questions were used covering these areas.

APPLICATION OF DATA

Random Sample Selection in Schenectady

Before this study was undertaken, there was no information as to who, within any population area, drove or did not drive a car. In seeking to provide these data, a sample area of Schenectady was selected to which could be applied area probability techniques. This meant that city blocks were selected at random and people on those blocks were selected for contact by an unbiased procedure.

Chief reliance was placed on census block statistics. The outline of the selected block was drawn on 8½-by 11-in. paper and put in a folder along with interview schedules and diary forms to make a working sheet for the interviewer. The interviewer's first step in the field was to ascertain the correctness of the boundaries before he drew in the number of households. Of the 873 blocks listed by the census, 14 densely-settled and 183 lightly-settled blocks formed the final sample. Distribution of these is shown in Figure 1.

In this work, a household was defined as a group of people sharing the same kitchen and other facilities.

At the start of the survey, one or two drivers were arbitrarily assigned to each fourth household (each sixth household for the dense blocks). An assignment of one meant that the oldest driver in the household was to be interviewed. Assignment of two meant an interview with the second oldest driver. In households having only one driver, but where a random start of two had been assigned, no driver was interviewed. In households with several drivers and a random start of one assigned, the first and

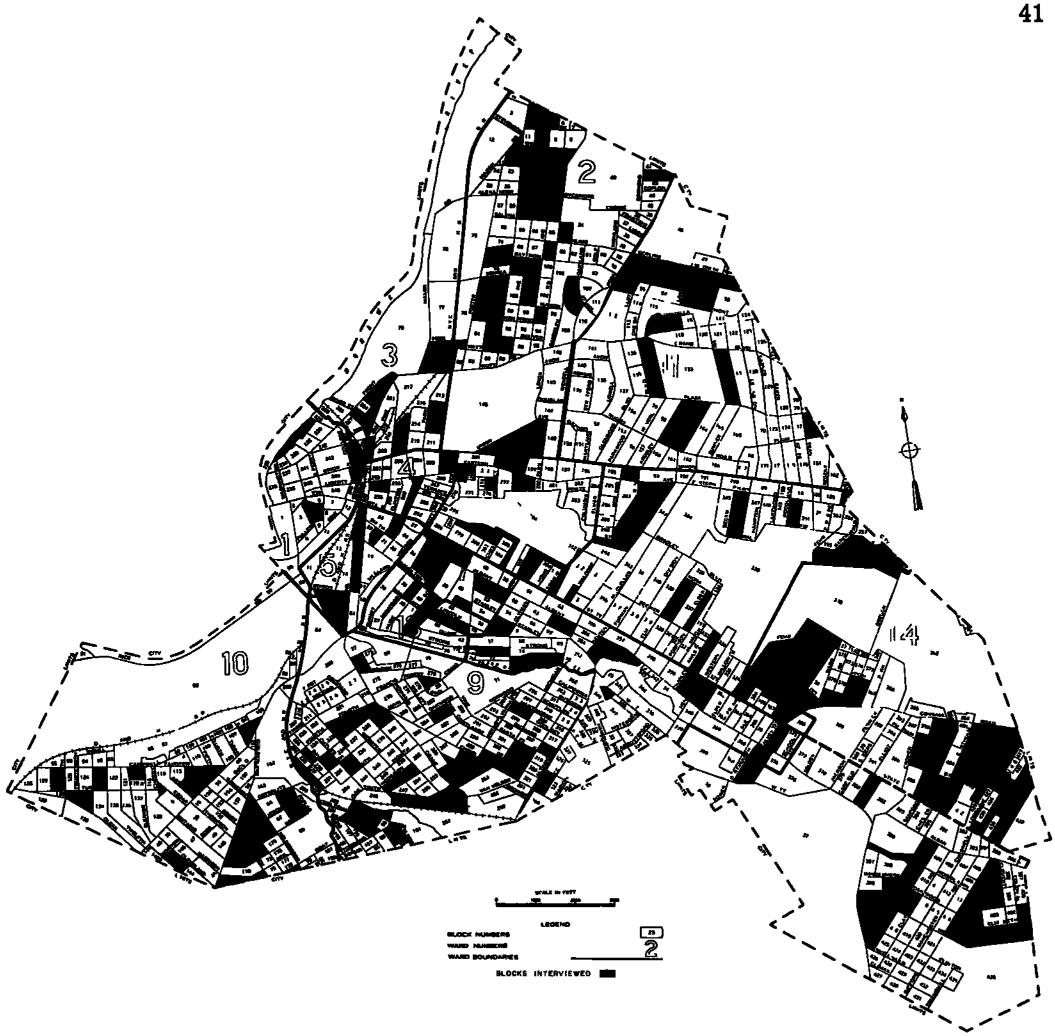


Figure 1. Schenectady, New York, by Wards and Blocks, 1950.

third oldest drivers were to be interviewed. With a random start of two, the second, fourth, and sixth oldest drivers were to be interviewed. The purpose of this procedure was to restrict the number of multiple-interviews in a given household in order to secure a wider spread of households, improve the pattern of sampling, and eliminate biases that might arise from people hearing a family member answering the same questions he had been asked or would be asked.

People were revisited until contact was made. The prediction was borne out very early that the only feasible times for interviewing were evenings and weekends.

The Interviewing

Interviewers were trained by the Project Director, initially through a "guide" written for them, and then by supervised practical work.

Interviewing of Schenectady drivers began on August 8, 1955, and continued until January 30, 1956. Some 810 drivers were completely interviewed; 757 others were contacted at least once for basic household data.

Diary-Keeping and Follow-Up

At the close of the interview, the driver was asked if he would be willing to keep a daily record of all miles driven. Respondents were told that an account of their driving

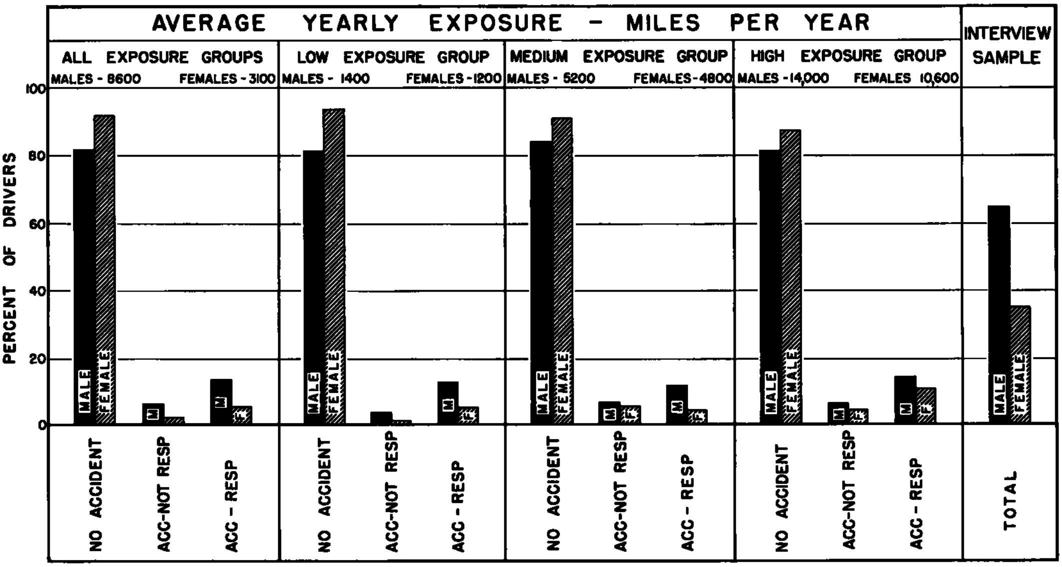


Figure 2. Sex of drivers compared with exposure (miles driven) and accident status for the period from January 1, 1953 through June 30, 1955.

would be collected at the end of each week for the four succeeding weeks. Most people readily agreed to do this and took the diary form, to which was attached a note from the Project Director thanking them for the interview, explaining something about the diary, and indicating where contact could be made with the project staff at City Hall. As the person finished four weeks, he was sent another thank-you letter from the Project Director for keeping the record.

A test was made to determine which of three follow-up methods brought the best cooperation and at the same time was most efficient to carry on. This was accomplished through three random subsamples of the blocks selected for interviews. In one subsample, everyone interviewed on the blocks chosen was sent a double, self-addressed postcard each week on which to copy the daily mileage from their diary before dropping it in the mail. Respondents in the second subsample were phoned each week and their mileages noted on their office copy directly. In the third subsample, drivers were visited each week in order that mileage could be copied on the office record directly at the doorstep. On October 26, 1955, an analysis was made of the three follow-up procedures in order to decide which should be carried on during the remainder of the study.

As a result of these analyses, the weekly follow-up for the remainder of the project was made by telephone, except for home visits to the approximately 10 percent who did not have phones.

Accident Record Search and Evaluation

Motor vehicle accidents, for the purpose of this study, were limited to those reported to and filed by the Bureau of Motor Vehicles. By statute, this includes all accidents involving personal injury or property damage of $50 or more.

Upon completion of their search the Bureau returned the index cards for each respondent, together with photostats of all corresponding accident reports. The photostats were then released for evaluation of accident responsibility.

A panel of 15 persons acted as judges for evaluating accident responsibility. Among these were five engineers, five statisticians, and five others, including physicians, a public health nurse, a cultural anthropologist and an insurance evaluator. The 15 were divided into five teams of three members each by selecting at random one engineer, one statistician, and one of the others.

To remove bias in judging, photostatic copies of the accident records were identified by number only. Name, age, sex, and color were obliterated. The records were divided into groups and each group sent to a team. If all three on a team assigned responsibility to the same driver on a record, judging was complete, since this is a majority decision of five. If the agreement was not complete on a record, it was sent to two more evaluators. Responsibility for each accident was thus determined by majority decision of five.

Accident responsibility was defined as any percentage attributable to a driver. Drivers in the "accident-not-responsible" category thus were judged as having zero responsibility for the accidents.

Coding, Punching, and Tabulating Interview Data

Coding was done as a separate operation. Data from the schedules were punched into five Holerith cards and information about accidents was punched on the sixth card. These cards formed the basis for tabulation by use of IBM equipment.

TABLE 2

CONTACT WITH HOUSEHOLDS

Nature of Contact	No-Interview Contacts		Interview Contacts		Total Contacts	
	Number	Percent	Number	Percent	Number	Percent
Driver interviewed	-	-	810	99.9	810	51.7
Wrong random start	8	1.1	-	-	8	0.5
No driver in household	341	45.0	-	-	341	21.8
Refusal: should be driver	18	2.4	-	-	18	1.1
Refusal: wrong random start or no driver	5	0.6	-	-	5	0.3
Refusal: household composition unknown	12	1.6	-	-	12	0.8
No contact could be made	87	11.5	-	-	87	5.6
No random start (start was 2 and only 1 driver)	276	36.5	-	-	276	17.6
Refusal: no random start driver in household	5	0.6	-	-	5	0.3
Interviewer failed to get interview	5	0.6	-	-	5	0.3
Totals	757	99.9	810	99.9	1,567	100.0

ANALYSIS OF DATA

Control Data

Control data are those which help form the background for evaluation of other findings in a study. Some of these can be indicated here.

A total of 1,567 contacts was made in Schenectady. These contacts made up the basic sample of the city. Of these, 810 were driver contacts. The remaining 757 were no-interview contacts. The latter group contained households in which no one had driven since January 1953, in which there was one driver but a random start of two, in which no complete contact could be made after one to six visits because of termination of the field work, and a very few in which the person refused to give more than a fragment of the information needed. Table 2 shows the nature of contacts with Schenectady households. Other analyses of the control data are shown in Appendix C.

Accident Evaluation

Of the 810 interviewed drivers, 119 were found to have been involved in motor vehicle accidents. Among the 119, 11 had had two and 2 had had three, making a total of 134 accident records on file with the Bureau of Motor Vehicles from January 1, 1953 through June 30, 1955. For comparative purposes, the average yearly accident rate for the sample was 0.066, as compared to the statewide average yearly rate of 0.057 for the same period.

Responsibility for each of the 134 accidents was judged separately. In the tabulations, 691 drivers were classified as no-accident; 82, involved in 88 accidents, as accident responsible; and 37, involved in 46 accidents, as accident not-responsible. The number of accidents, is shown in Table 3 and judged accident responsibility.

TABLE 3

NUMBER OF ACCIDENTS BY TYPE AND JUDGED DRIVER RESPONSIBILITY

Driver Responsibility	Head On	Rear End	Angular	One Car	Pedestrian	Others	Total
Responsible	6	36	21	12	5	8	88
Not Responsible	2	18	5	16	2	3	46
Total	8	54	26	28	7	11	134

106 drivers with one accident
11 drivers with two accident
2 drivers with three accidents
119 drivers = 134 accidents

Data Arrangement by Exposure

A serial tabulation of miles driven during a 2½-yr period by 810 drivers showed the range to be from 0 to 161,000. For arrangement by exposure, the 810 drivers were simply divided into three groups of 270 each. For the first 270 respondents, the mileage driven ranged from 0 to 7,600. The second group of 270 drove from 7,601 to 18,100 mi and was called the medium exposure group. The third group drove from 18,101 to 161,000 mi and was called the high exposure group.

TABLE 4

DRIVERS COMPARED BY EXPOSURE (MILES DRIVEN) AND ACCIDENT STATUS

Exposure Category	No Accident		Accident Responsible		Accident Not Responsible		Total	
Miles	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Low 0 - 7,600	243	90	21	8	6	2	270	100
Medium 7,601-18,100	231	86	24	9	15	6	270	100
High 18,101-161,000	217	80	37	14	16	6	270	100
Total	691	85	82	10	37	5	810	100

With respect to the accident status, it can be noted that 21 accident responsible drivers were in the low mileage category, 24 were in the medium, and 37 in the high group. Table 4 shows these comparisons in greater detail.

Machine tabulations and percentages were then run for each tabulation of the 60 variables under study. A sample of these first-run tabulations is shown in Table 5.

TABLE 5

SAMPLE OF FIRST TABULATIONS RUN

May 1956 — COOPERATIVE RESEARCH PROJECT — Driver Behavior and Highway Safety Research
New York State Department of Public Works — New York State Department of Health — United States Bureau of Public Roads

Schenectady interviewed drivers compared by miles driven (exposure) and by accident status from January 1, 1953, through June 30, 1955, and by sex of respondent (interviewee)

Miles driven (exposure) and accident status (no accident, accident responsible, and accident not responsible) Card VI, Cols 35-40

Card ... Cols ...		Low Mileage (0 - 7,600)								Medium Mileage (7,601 - 18,100)								High Mileage (18,101 - 161,000)								TOTALS							
		No Acc		Ac Re		ANR		Total		No Acc		Ac Re		ANR		Total		No Acc		Ac Re		ANR		Total		No Acc		Ac Re		ANR		Total	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
1 Male	1	74	30	12	57	4	67	90	33	162	70	21	88	11	73	194	72	193	89	34	92	15	94	242	9	429	62	67	82	30	81	526	65
2 Female	2	169	70	9	43	2	33	180	67	69	30	3	13	4	27	76	28	24	11	3	8	1	6	28	10	262	38	15	18	7	19	284	35
Total		243	100	21	100	6	100	270	100	231	100	24	101	15	100	270	100	217	100	37	100	16	100	270	100	691	100	82	100	37	100	810	100

Testing of Hypotheses

Committee Decisions. The committee suggested testing all hypotheses by controlling for exposure (miles driven) and accident status. This was accomplished for the 60 variables studied. Examination of these data led to recommendations for regrouping the responses in the individual tabulations. Of still greater importance, however, was the decision to segregate and analyze the data separately for the male and female drivers. This decision was based on a comparison of the accident status of the males and females, which showed a higher percentage of the males in the accident responsible and accident not-responsible categories than the females for all exposure groups.

This comparison of the accident status of male and female respondents in the several exposure groups is depicted in Figure 2. Men were in higher proportion in the accident responsible and accident not-responsible categories than were women for low, medium, and high exposure, and for all exposure considered together.

Approximately one out of every 5 male drivers was involved in an accident during the 2½-year period of investigation from January 1, 1953 through June 30, 1955 whereas only one out of every 13 female drivers was involved in an accident within the same

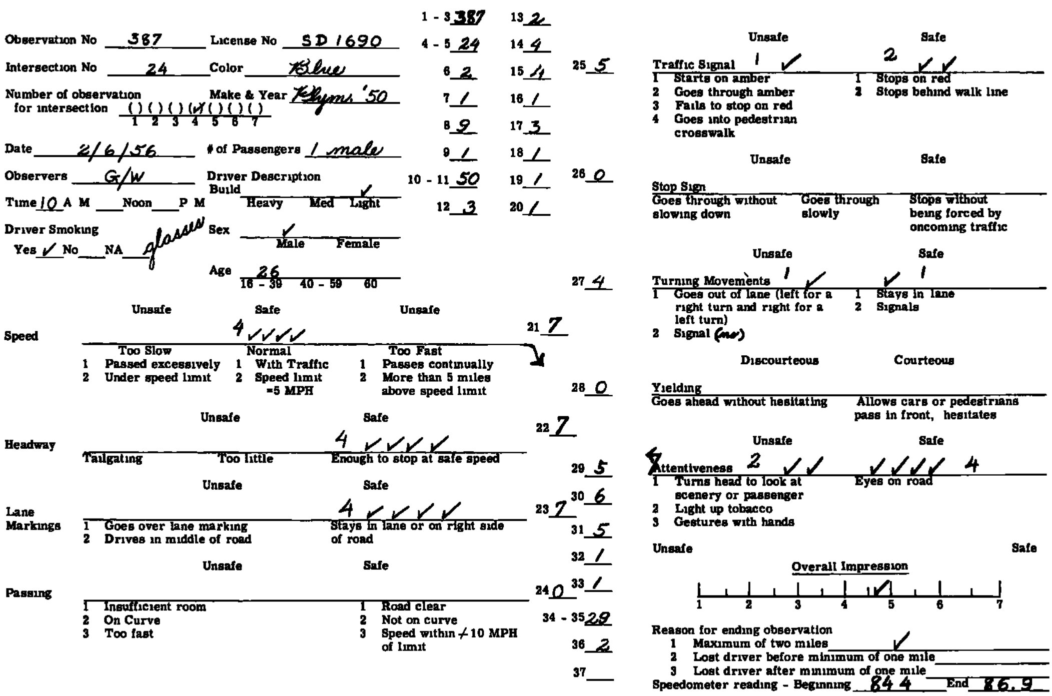


Figure 3. Scales for observing drivers in Schenectady.

period. Without taking exposure into account, statistical test showed that this difference is significant; on this basis the null hypothesis of no difference in accident status according to sex might be rejected at this point and further supports separate analysis of the characteristics of male and female drivers.

This hypothesis testing by inspection was subject to further study by tests for statistical significance before deciding whether or not to reject the general null hypothesis that drivers who are involved in accidents do not differ from those who are accident free.

Statistical Tests for Confidence Levels. Using the total figures (for all exposure groups) and based on the closeness of the actual frequency of the responses to that of the theoretical, inspection of the tabulated data revealed that the data for 28 of the 60 variables would yield no appreciable confidence levels. The general null hypothesis that drivers who are responsible for accidents do not differ from those who are not responsible for accidents or those who are accident free could not be rejected with respect to these 28 variables (Table 6).

TABLE 6

VARIABLES WHICH FROM INSPECTION OF DATA YIELDED NO APPRECIABLE CONFIDENCE LEVELS

Table No. of Variable	Variable
4	Length of driving experience
5	Make of car driven most at present
6	Year of vehicle driven most at present
7	Instructor when learning to drive
13	How they feel when they drive
16	Satisfaction with mechanical performance and the way the car drives
17	Satisfaction with the appearance of the car they drive
18	Opinion of people's driving according to the way they feel
20	Affect on driving when they are angry
21	Affect on driving when they are sad or depressed
29	Weight of respondent
30	Whether or not they have hay fever
31	Whether or not they have asthma
32	Whether or not they have diabetes
33	Whether or not they have high blood pressure
34	Whether or not they have a stomach ulcer
35	Whether or not they have arthritis, rheumatism or neuritis
36	Whether or not they have limited use of either arm or leg
37	Whether or not they have fainting spells or epilepsy
38	Whether or not they ever had nervous or emotional illness
39	Whether or not they ever had chronic condition or long drawnout illness
40	Whether or not they have trouble hearing
41	Whether or not they have trouble getting to sleep
46	Opinion of own driving skill
48	Opinion about most people noticing warning signs on the road
49	Opinion on stop signs being generally observed
59	Total score of house and neighborhood of drivers
60	Occupation

As previously noted, a comparison of the accident status of the males and females showed a higher percentage of the males in the accident responsible and accident not-responsible categories than the females in all exposure groups. This relation was statistically significant at a 99 percent confidence level. As a result, the remaining 31 variables were examined by sex; otherwise, the sex factor may have masked or distorted the presence and influence of the other variables. Thus, for each of these

TABLE 7

CONFIDENCE LEVELS OF VARIABLES (DATA) TESTED FOR "ALL EXPOSURE GROUPS" BY CHI-SQUARE METHOD

Table No. of Variable	Variable	Confidence level	
		Males	Females
1	Size of household	0.63	0.62
2	Age of respondent	0.13	0.51
8	Number of times exam taken for first license	0.44	0.58
9	Highest grade or year completed in school	0.82	0.82
10	Present marital status	0.97	0.90
11	Present labor force status	0.53	0.89
14	Whether or not they enjoy driving	0.49	0.49
15	Their opinion of night driving	0.20	0.38
19	If driving relaxes one when disturbed about something with other people	0.19	0.46
22A	Their opinion of how nervous they are	0.04	0.45
22B	What is done to wake up when sleepy at the wheel	0.04	0.70
23	Their share of worries the last three years	0.01	0.10
24	Whether they smoke now and whether they have smoked in the last three years	0.40	0.79
25	How much they smoke now	0.07	0.42
26	Whether or not they smoke while driving	0.16	0.74
27	Whether or not they drink	0.35	0.70
28	Whether or not they drive after drinking on occasion	0.44	0.25
42	Whether or not they wear glasses	0.13	0.22
43	Whether or not they have been wearing sun-glasses on sunny days.	0.53	0.65
44	Usual speed on the open road with no speed control signs	0.03	0.85
45	Whether or not they think other drivers are courteous	0.12	0.08
47	Opinion of whether a slow or fast driver	0.03	0.22
50	Their opinion about the necessity of drivers coming to a full stop at a corner stop sign	0.13	0.68
51	Their relative ease of finding their way on a strange road	0.99	0.42
52	Their opinions about the size of route signs	0.72	0.56
53	Fastest ever driven on the open highway	0.16	0.27
54	Number of times stopped along the road because of car breakdown since January, 1953	0.62	0.49
55	Opinion of whether or not traffic laws are enforced strictly enough	0.46	0.81
56	Total family income for 1954	0.69	0.59
57	Type of dwelling of driver	0.94	0.05
58	Type of neighborhood area driver's house is in	0.40	0.45

variables, the responses under the totals column (all exposure group) for each of the three categories of drivers (no-accident, accident and responsible, and accident not-responsible) by sex, were tested simultaneously by the chi-square method. A 95 percent confidence level was considered as statistically significant.

TABLE 8

VARIABLES SELECTED FOR FACTOR ANALYSIS FOR MALE AND FEMALE DRIVERS, FIRST RUN[a]

Table No. of Variable	Variable	Method of Selection	Selected for Male	Selected for Female
1	Size of household	2	X	
9	Highest grade or year completed in school	2	X	X
10	Present marital status	1	X	
11	Present labor force status	2		X
23	Their share of worries in last 3 years	2	X	
24	Whether they smoke now and in past 3 years	3	X	X
25	How much they smoke now	3		X
27	Whether or not they drink	2	X	
25	Whether or not they drive after drinking	2	X	
42	Whether or not they wear glasses	2	X	
43	Whether or not they wear sunglasses on sunny days	2	X	X
44	Usual speed on the open road w/no speed control signs	2	X	
47	Opinion of whether a slow or fast driver	2		X
51	Their relative ease in finding their way on a strange road	1	X	X
55	Opinion of whether or not traffic laws are enforced strictly enough	2		X
59	Driving instructor when learning to drive	2	X	
Total			12	8

[a] All variables analyzed for totals; all exposure groups only

Table 7 indicates that for the male drivers the responses for only two of the variables met the qualification for statistical significance. None of the data for the female drivers reached the 95 percent confidence level for statistical significance.

Factor Analysis, First Run. In order to further interpret the data, it was appropriate to introduce a "factor analysis," which is used to determine the underlying influences on apparent differences in the various distributions of the data.

Variables by sex, as shown in Table 8, were selected for analysis in the first run, using one of the following three criteria:

1. A chi-square test of significance gave a confidence level of 95 percent or better.
2. Judgment wherein the various attributes were studied and, in general, selecting those with the largest diversion from expectation.
3. The current interest of the item.

It is to be noted that the data in the total or "all exposure" groups were used for this investigation. These results are not discussed here as they were exploratory in nature.

Factor Analysis, Second Run. The foregoing factor analysis was applied to all the drivers in the sample by sex. In order to consider the influence of exposure on the apparent differences in the various distributions of the data, 19 variables for the male and 17 variables for the female drivers (Table 9) were selected for a second-run factor analysis. The same method of selecting the variables for study was used as in the first-run analysis.

However, for analysis both the male and female drivers were divided into three

TABLE 9

VARIABLES SELECTED FOR FACTOR ANALYSIS FOR MALE AND FEMALE DRIVERS, SECOND RUN[1]

Table No. of Variable	Variable	Method of Selection	Selected for Males	Selected for Females
1	Size of household	2	X	X[2]
2	Age of respondent	3	X[2]	X[2]
4	Length of driving experience	3	X[2]	X[2]
6	Year of vehicle driven most at present	3	X[2]	X[2]
7	Driving instructor when learning to drive	2	X	X[2]
9	Highest grade or year completed in school	2	X	X
10	Present marital status	1	X	X[2]
11	Present labor force status	2		X
15	Their opinion of night driving	3	X[2]	X[2]
23	Their share of worries last 3 years	2	X	
24	Whether they smoke now and in past 3 years	3	X	X
25	How much they smoke now	3	X[2]	X
26	Whether or not they smoke while driving	3	X[2]	
27	Whether or not they drink	2	X	
28	Whether or not they drive after drinking	2	X	
42	Whether or not they wear glasses	2	X	
43	Whether or not they wear sunglasses on sunny days	2	X	X
44	Usual speed on the open road w/no speed control signs	2	X	X[2]
46	Opinion of driving skill	3	X	X
47	Opinion of whether a slow or fast driver	1		X
51	Their relative ease in finding their way on a strange road	1	X	X
55	Opinion of whether or not traffic laws are enforced strictly enough	2		X
Totals			19	17

[1] In addition to first run
[2] All variables analyzed by four exposure groups, low, medium, high and totals

nearly equal groups with totals, groups, and the corresponding accident involvement data, for the range of answers given for each variable, and were tabulated accordingly. In the first instance the multiple-accident drivers were excluded from the analysis, for which all drivers and all accidents were used as a base.

For the first 175 male drivers (low exposure group) the mileage driven for the 2½-year period ranged from 0 to 12,600. The medium exposure group (176) drove from 12,601 to 22,900 miles and the high exposure group (175) drove from 22,901 to 161,000 miles. Likewise, for the female drivers the first group (95), the second group (96), and third group (95), drove from 0 to 2,700, 2,701 to 8,500, and 8,501 to 40,800 miles, respectively, during the 2½-year period.

Separate factor analyses were performed for each of these exposure groups and the total group for both male and female drivers. For the male drivers, 19 sets of intercorrelation were performed, intercorrelating each variable with the other 18, thus pro-

TABLE 10

CHARACTERISTICS OF VARIABLES FOR MALE DRIVERS WHICH WERE UNDERLYING FACTORS IN THEIR ASSOCIATION WITH ACCIDENTS, BY EXPOSURE GROUPS - SCHENECTADY INTERVIEW

Variable for the male drivers	Exposure		Group	
	Low (2,800)*	Medium (6,400)*	High (16,200)*	Totals (8,600)*
	Unfavorable	Characteristic	for those	
Size of household	- - - -	- - - -	- - - -	- - - -
Age of respondent	in middle age group	in middle age group	in middle age group	in middle age group
Length of driving experience	with 10 to 19 years of experience	- - - -	- - - -	- - - -
Year of vehicle driven most at present	- - - -	who drove older models than '53 and later models than '54	- - - -	who drove older models than '53 and later models than '54
Driving instructor when learning to drive	- - - -	other than self	- - - -	- - - -
Highest grade or year completed in school	who did not finish high school	- - - -	who did not finish high school	who did not finish high school
Present marital status	- - - -	who were single	who were single	who were single
Objection to night driving	other than who didn't object	other than who didn't object	other than who didn't object	other than who didn't object
Their share of worries last 3 years	- - - -	- - - -	- - - -	- - - -
Whether they smoke now and in past 3 years	- - - -	who smoked	who smoked	who smoked
How much they smoke now	- - - -	- - - -	- - - -	- - - -
Smoke while driving	- - - -	- - - -	- - - -	- - - -
Whether or not they drink	who drank[1]	- - - -	who drank[1]	who drank
Drive after drinking	who drove after drinking[1]	- - - -	who drove after drinking[1]	- - - -
Wear glasses or not	who did not wear glasses	- - - -	who did not wear glasses	- - - -
Whether or not they wear sunglasses on sunny days	- - - -	- - - -	- - - -	who usually wore sunglasses
Usual speed on the open road w/no speed control signs	who drove at speeds higher than 50 mph[1]	who drove at speeds higher than 50 mph	who drove at speeds higher than 50 mph[1]	- - - -
Opinion of driving skill	- - - -	who rated themselves as average	- - - -	who rated themselves as average
Their relative ease in finding their way on a strange road	who had no difficulty	- - - -	- - - -	who had no difficulty
(EXPOSURE)	N A	N A	N A	- - - -
	9 of 19 variables = factors	8 of 19 variables = factors	9 of 19 variables = factors	10 of 19 variables = factors

*Average miles driven per year for period January 1, 1953 through June 30, 1955

[1] Three variables together (safety-mindedness)

TABLE 11

CHARACTERISTICS OF VARIABLES FOR FEMALE DRIVERS WHICH WERE UNDERLYING FACTORS IN THEIR ASSOCIATION WITH ACCIDENTS FOR ALL EXPOSURE GROUPS - SCHENECTADY INTERVIEW

Variable for the female drivers	Exposure		Group	
	Low (500)*	Medium (2,100)*	High (6,600)*	Totals (3,100)*
	Unfavorable	Characteristic	for those	
Size of household	with 1 or 2 in household	- - - -	with 1 or 2 in household	with 1 or 2 in household
Age of respondent	in younger & older age groups	in younger & older age groups	in younger & older age groups	in younger & older age groups
Length of driving experience	- - - -	- - - -	- - - -	- - - -
Year of vehicle driven most at present	- - - -	who drove older models than '53	- - - -	- - - -
Driving instructor when learning to drive	- - - -	- - - -	- - - -	who were not taught by a relative
Highest grade or year completed in school	who did not finish high school	- - - -	who did not finish high school	- - - -
Present marital status	who were presently married	- - - -	- - - -	- - - -
Present labor force status	- - - -	who were housewives	who were housewives	who were housewives
Objection to night driving	- - - -	- - - -	- - - -	other than who didn't object
Whether they smoke now and in past 3 years	- - - -	- - - -	who did not smoke	who did not smoke
How much they smoke now	- - - -	- - - -	- - - -	- - - -
Whether or not they wear sunglasses on sunny days	who usually wore sunglasses	- - - -	who usually wore sunglasses	who usually wore sunglasses
Usual speed on the open road w/no speed control signs	- - - -	- - - -	- - - -	- - - -
Opinion of driving skill	who rated themselves other than average[1]	- - - -	who rated themselves other than average	who rated themselves other than average
Opinion of whether a slow or fast driver	other than slow drivers[1]	other than slow drivers	other than slow drivers	- - - -
Their relative ease in finding their way on a strange road	- - - -	who had difficulty	who had difficulty	- - - -
Opinion of whether or not traffic laws are enforced strictly enough	- - - -	who said no	who said no	- - - -
(EXPANSION)	N A	N A	N A	in higher exposure group
	7 variables of 17 = factors	6 variables of 17 = factors	10 variables of 17 = factors	9 variables of 18 = factors

*Average miles driven per year for period January 1, 1953 through June 30, 1955

[1] Two variables together

ducing 702 indices of association with accident status. Similarly, for the female drivers 561 indices of association with accident status were produced.

Table 10 shows the characteristics of the variables for male drivers which were underlying factors (unfavorable characteristics) in their association with accidents by exposure groups. Four variables did not give any evidence of being underlying factors associated with accident status. Being in the middle age group (30 to 49 years of age) and those who did object to night driving were unfavorable characteristics of male drivers in accident association fcr all exposure groups. In the examination of the totals group, exposure was not found as an underlying factor for male drivers in their association with accidents. Three of the factors appeared as unfavorable characteristics in but one exposure group, five appeared in two groups, five appeared in three groups, and two appeared in all four groups.

Table 11 shows the characteristics of the variables for female drivers which were underlying factors (unfavorable characteristics) in their association with accidents by exposure groups. Three variables did not give any evidence of being underlying factors associated with accident status. Being in the younger (under 30 years of age) and the older (over 49 years of age) groups of female drivers were unfavorable characteristics in accident association for all exposure groups. In the examination of the total group, exposure in the average yearly range of from 2,000 to 16,000 miles for female drivers was found as an underlying factor in their association with accidents. Two of the factors appeared as unfavorable characteristics in but one exposure group, four appeared in two groups, five appeared in three groups, and one appeared in all four groups.

Table 12 shows the consensus of characteristics of variables for male and female drivers which were underlying factors in their association with accidents, for all exposure groups. The basis for these factors was obtained from analyzing the data for male and female drivers in the four exposure groups and comparing results for consistency within the groups.

It appears that for the drivers studied, those with the following characteristics are more apt to be associated with accidents than those without:

MALE DRIVERS

1. Between 30 and 49 years of age
2. Who drive older models than '53 and later models than '54
3. Who did not finish high school
4. Who are single
5. Who do object to night driving
6. Who smoke
7. Who drink
8. Who drive after drinking
9. Who usually wear sunglasses while driving
10. Who drive at speeds greater than 50 mph
11. Who rate themselves as average drivers
12. Who have no trouble finding their way on strange roads

FEMALE DRIVERS

1. With one or two in household
2. Under 30 and over 49 years of age
3. Who did not finish high school
4. Who are housewives
5. Who do not smoke
6. Who usually do not wear sunglasses while driving
7. Who rate themselves as other than average drivers
8. Who have difficulty in finding their way on strange roads
9. Who believe that traffic laws are not enforced strictly enough
10. In higher exposure group (over 2,000 miles per year)

The balance of the variables selected for study did not give evidence of being underlying factors associated with accident status. However, it must be considered that, except for exposure for females, the variables when tested individually did not reach significance. Thus, these results could not be readily applied to any other group of drivers except the group studied, without additional investigation.

Analysis of Distribution of Answers. The distribution of the answers for each variable selected for factor analysis (Table 9) was examined to determine trends in the data. The detailed results of this study are shown in Appendix A.

PART II. DRIVER OBSERVATION OF A SAMPLE OF DRIVERS
Determination of Data

The interdepartmental committee, in the initial planning for the study, decided to observe persons driving in Schenectady in order to test the hypothesis that there is no difference between accident and no-accident drivers in the way they drive. This part of the research was considered important, as it is postulated that practice in ordinary driving may be related to what occurs in an emergency situation or accident.

The nature of this phase of the study made it necessary to construct, test, and standardize scales on which the different aspects of a person's driving could be recorded objectively and reduced to a score for comparative purposes. Because little has been done to relate ordinary driving to other characteristics of persons, including their driving experience, accidents, personality, attitudes, and related information collected in the first past of this study, it was hoped that a method could be devised to either observe the persons interviewed or interview the drivers observed.

No practical method could be determined to observe persons driving subsequent to the interview and the time element of the project would not support the interview of persons after driver observation. Thus, it was decided that the scope of this phase of the study would be limited to relating observed driving characteristics to the subject's accident experience, as reported to the Motor Vehicle Bureau, for the period January 1, 1953, through June 30, 1955.

TABLE 12

CONSENSUS OF CHARACTERISTICS OF VARIABLES FOR MALE AND FEMALE DRIVERS WHICH WERE UNDERLYING FACTORS IN THEIR ASSOCIATION WITH ACCIDENTS FOR ALL EXPOSURE GROUPS - SCHENECTADY INTERVIEW

Variable for the drivers	Drivers	
	Male (8,600)*	Female (3,100)*
	Unfavorable characteristic for those	Unfavorable characteristic for those
Size of household	------	with 1 or 2 in household
Age of respondent	in middle age group	in younger & older age groups
Length of driving experience	------	------
Year of vehicle driven most at present	who drove older models than '53 and later models than '54	who drove older models than '53
Driving instructor when learning to drive	------	who were not taught by a relative
Highest grade or year completed in school	who did not finish high school	who did not finish high school
Present marital status	who were single	------
Present labor force status	N A	who were housewives
Objection to night driving	other than who didn't object	------
Their share of worries last 3 years	------	N A
Whether they smoke now and in past 3 years	who smoked	who did not smoke
How much they smoke now	------	------
Smoke while driving	------	N A
Whether or not they drink	who drank[1]	N A
Drive after drinking	who drove after drinking[1]	N A
Wear glasses or not	------	N A
Whether or not they wear sunglasses on sunny days	who usually wore sunglasses	who usually did not wear sunglasses
Usual speed on the open road w/no speed control signs	who drove at speeds higher than 50 mph[1]	------
Opinion of driving skill	who rated themselves as average	who rated themselves other than average
Opinion of whether a slow or fast driver	N A	------
Their relative ease in finding their way on a strange road	who had no difficulty	------
Opinion of whether or not traffic laws are enforced strictly enough	N A	------
(EXPOSURE)	------	in higher exposure group
	12 of 20 variables = factors	10 of 18 variables = factors

*Average miles driven per year for period January 1, 1953 through June 30, 1955

[1] Three variables together (safety-mindedness)

Scales

A scale for recording the actions of drivers being observed was developed only after evaluation of the results of pretesting several types of forms. Figure 3 is a reproduction of a completed form with scales adopted for use.

Scales with two or three sections were designed to note safe and/or unsafe actions concerning speed characteristics, headway allowed, observations of lane markings, judgment used in passing, compliance with traffic signals, respect for stop signs, method of turning, willingness to yield right-of-way to others, attentiveness to driving, and the over-all impression of the driver's ability. Also, selection of easily identified driver characteristics was listed, together with an outline description of both driver and car, including the car's registration plate number. Space was provided on the form for coding the recorded information.

Scoring System

A point scoring system using the ratio of safe to unsafe observations was adopted and applied to each scale individually, as follows:

Number of Points	Observations Safe	Observations Unsafe
0	None	None
1	None	3 or more
2	None	1 or 2
3	1	More than 1
4	1	1
5	More than 1	1
6	1 or 2	None
7	3 or more	None

Number of Observations

It was originally planned to obtain a sample of seven different driver observations originating at each of 50 randomly selected intersections within the corporate limits of Schenectady. Provisions were made to extend this into February 1956, using eight different driver observations for a second sample of 32 intersections. Figure 4 shows the intersections used in each selection. The number of drivers observed at each intersection was planned to be in proportion to the average traffic volume, during the hour of the day observed. No observations were to be made on Saturdays or Sundays and between the hours of 11:00 P.M. to 7:00 A.M.

Other Considerations

The techniques for the observations also included the following committee decisions:

1. Drivers to be followed and observed for a minimum of 1 mi and maximum of 2 mi.
2. One-half of the intersection samples each from inbound and outbound traffic.
3. Selection of cars passing intersections for observation in series of three (3rd, 6th, or 9th).
4. Indicate if driver was smoking or not.
5. Indicate if driver wore glasses.

APPLICATION OF DATA

A team for the observation of drivers consisted of a driver and an observer. Before operations started, a chart for control purposes listing the number of observations to be taken during the various time periods at each of the numbered intersections was prepared. The observations were checked off as they were completed.

In tailing cars, particular attention was given to maintaining a respectable distance between cars to prevent the observed driver from becoming aware of being followed. When it became apparent that the driver was aware of being followed, the observation was cancelled.

Procedure Particular to Items

Figure 3 shows the descriptions of the actions to be checked for each item of driver observation to be rated, thus simplifying the field work. Also, situations which the driver was forced into by traffic conditions were not subiect to rating.

Motor Vehicle Bureau Accident Search

At the end of each day, the vehicle registration plate numbers, together with the observation numbers, were transferred from the observation forms to individual Motor Vehicle Bureau "Information Request" forms (Figure 5).

Thus, the owner of the car was identified and accident records from January 1, 1953, through June 30, 1955, secured. When the field description of the driver did not match the owner, a personal contact was made with the owner and the driver's identity secured.

Each item of driver observation was scored using the system described. The results of the scoring, the common items recorded on the observation forms, information from the listings of the accident file cards, and type of accidents, were coded and placed on the individual observation forms.

This coded information was transferred to punch cards, which formed the basis for the analysis of the data.

TABLE 13

DRIVERS OBSERVED IN SCHENECTADY COMPARED BY NUMBER OF PERSONS IN CAR INCLUDING DRIVERS

Number of Persons In Car	Drivers, Number	Percent of Total	Average Occupancy, Number
1	301	55	
2	158	29	
3	49	9	
4	16	3	
5	6	1	
6	2	-	
Not observed	18	3	
Total	550	100	1.6

TABLE 14

DRIVERS OBSERVED IN SCHENECTADY COMPARED BY DAY OF WEEK OBSERVATIONS WERE MADE

Day of Week	Number	Percent
Monday	96	17
Tuesday	86	16
Wednesday	147	26
Thursday	130	24
Friday	91	17
Total	550	100

ANALYSIS OF DATA

Procedure

Tabulations were run from the cards for each common characteristic of the drivers and cars by no-accident and accident drivers. The data relating to the number and type of accidents were collated with the various groups of accident drivers for comparison.

The same procedure was used in tabulating information for the items of driver behavior observed, except that the drivers were classified into five main groups according to the number of points used in scoring. For each item observed, those drivers with a score of 1 or 2 were grouped as unsafe; those with a score of 3, predominately unsafe; those with a score of 4, neutral; those with a score of 5, predominately safe; and those with a score of 6 or 7, safe.

Composition of the Sample

A total of 591 drivers was observed. Of these, 41 were not used as it was not possible to determine who drove. The remaining 550 (428 males and 122 females) formed the sample studied.

For these drivers, the Bureau of Motor Vehicles provided records of 96 males having a total of 119 accidents and 18 females with a total of 19 accidents for the period of investigation.

Number of Persons in Car. Table 13 compares the drivers observed by number of persons in the car including driver. Fifty-five percent of the drivers were driving alone when observed, whereas, 29 percent had only one passenger. The average occupancy (1.6 per car) appears to be representative of a typical metropolitan area.

Day of Week. A comparison of observations by day of week (Table 14) indicates that a higher proportion of observations were made on Wednesday and Thursday than on the other days of the week. Thus, for these two days about 5 percent more drivers were

TABLE 15

DRIVERS COMPARED BY SEX AND ACCIDENT EXPERIENCE

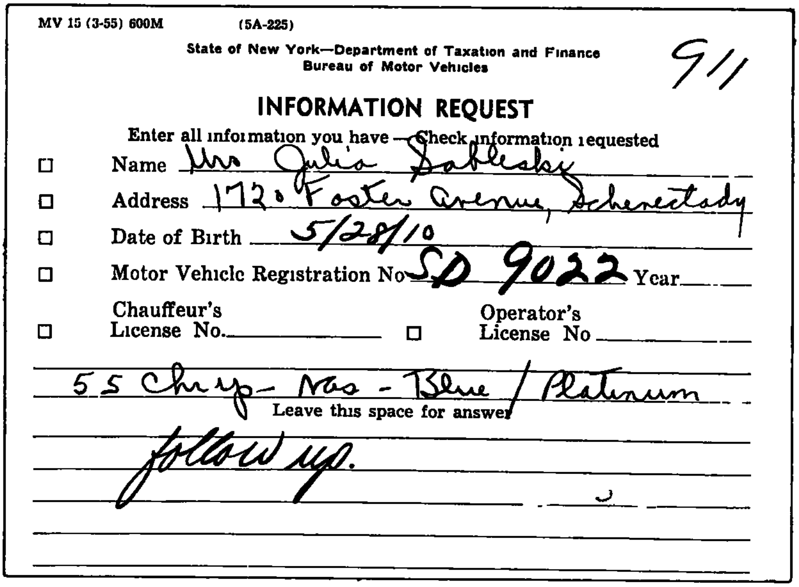
	DRIVERS												ACCIDENTS												
		NO-ACCIDENT		ACCIDENT		WITH								TYPE											
	All					1 Accident		2 Accidents		3 Accidents		Total	Head-On		Rear-End		Angular		Single Car		Pedestrian		Other	
	Number	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Male	428	332	77	96	23	76	18	17	4	3	1	119	0	0	35	29	51	43	25	21	7	6	1	1
Female	122	104	85	18	15	17	14	1	1	0	0	19	1	5	3	16	11	58	3	16	1	5	0	0
All	550	436	79	114	21	93	17	18	3	3	1	138	1	1	38	27	62	45	28	20	8	6	1	1

observed than would have been expected if they were randomly distributed. This difference could be expected, because it was not required that the observers make an equal number of observations during each day of the week.

Characteristics of Drivers and Accident Experience

Sex. Table 15 shows the sample composition by sex and accident experience from January 1, 1953, through June 30, 1955. Males represented 78 percent of the observed drivers, with 23 percent (or 1 in 4) involved in accidents, and females 22 percent, with 15 percent (or 1 in 7) involved. More of the males (5 percent) than the females (1 percent) were involved in more than one accident.

Figure 4. Schenectady, New York, by Wards and Blocks, 1950.



MV 15 (3-55) 600M (5A-225)

State of New York—Department of Taxation and Finance
Bureau of Motor Vehicles

911

INFORMATION REQUEST

Enter all information you have—Check information requested

☐ Name Mrs Julia Sableski

☐ Address 1720 Foster Avenue, Schenectady

☐ Date of Birth 5/28/10

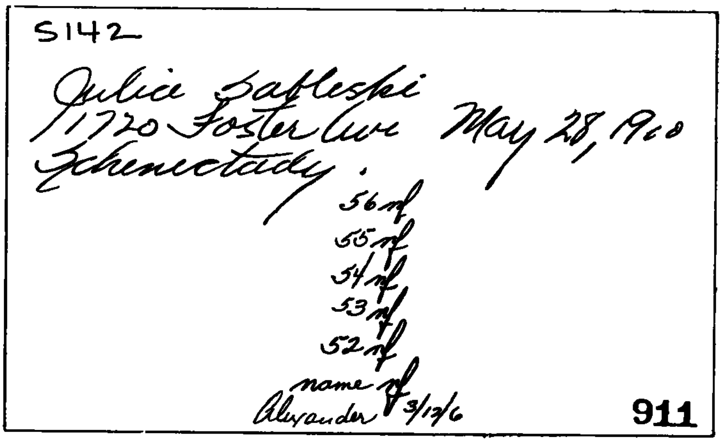
☐ Motor Vehicle Registration No SD 9022 Year

☐ Chauffeur's License No. ☐ Operator's License No

55 Chry- Nos - Blue / Platinum

Leave this space for answer

follow up.



S142

Julia Sableski
1720 Foster Ave May 28, 1910
Schenectady.

56 nf
55 nf
54 nf
53 nf
52 nf
name nf
Alexander 3/12/6

911

Figure 5. Sample forms used for motor vehicle bureau searches.

More than 90 percent of all accidents (Table 15) were of rearend, angular or single-car types, with one-half of these being angular. Although the females appeared to have a higher proportion of angular and smaller proportion of rearend and single-car accidents than did the males, the numbers are small and could be due entirely to chance.

Statistical Significance of Data. Examination of the distribution of the no-accident and accident groups of male and female drivers by (a) age, smoking while driving, and wearing of glasses; and (b) accident experience for cars by age and weight, indicated that there were no significant differences between these groupings.

Likewise, the results of chi-square significance tests indicated that the five-point scale did not discriminate, in any of the nine items of driver behavior observed, with significance between no-accident and accident drivers. No better results were obtained when the data were re-analyzed to determine if the frequency of the safe and unsafe observations for each item of driver behavior observed would discriminate among the groups of drivers.

Unsafe Driver Behavior Habits by Item

The five-point scale used for classifying driver behavior was narrowed down to a two-point scale for all drivers by placing all the unsafe, predominately unsafe, and neutral drivers into one group labeled "unsafe" and the balance into a "safe" group. The percentage of drivers guilty of unsafe actions, by rank for each item of driver behavior observed, is as follows:

Item of Driver Behavior	Unsafe Drivers, Percent
Stop sign	67
Yielding	36
Turning movement	35
Passing	19
Speed	17
Attentiveness	13
Lane markings	8
Headway	6

CONCLUSIONS—Phase II

From studies of driver behavior in Schenectady and related accident experience of the drivers as reported to the Bureau of Motor Vehicles, for the period January 1, 1953, through June 30, 1955, it may be concluded that:

1. Approximately one out of every four male drivers observed was involved in an accident, whereas only one out of every seven female drivers observed was involved in an accident during the same period. Without taking exposure into account, statistical test showed that this difference is highly indicative (confidence level 0.80) that female drivers are less likely to be involved in accidents than male.
2. There was no significant difference between:
   (a) The frequency of accidents by type.
   (b) Accident experience and either the age of the driver, or whether or not the driver was smoking or wearing glasses while driving.
   (c) Accident experience and either the weight classification or age of cars driven.
   (d) Accident and no-accident drivers in the way they drove.
3. The order of driver behavior habits by percentage of unsafe drivers was:
   (a) At stop sign.
   (b) Yielding practice.
   (c) Turning movements.
   (d) Passing maneuvers.
   (e) Speed.
   (f) Attentiveness.
   (g) At traffic signal.
   (h) Lane marking observance.
   (i) Headway.

ACKNOWLEDGMENTS

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Representatives from the three agencies constituted an interdepartmental committee to plan and guide the work as it progressed. Actively participating in the 14 committee conferences and pre-testing of techniques were: for the Bureau of Public Roads, Charles W. Prisk and E. L. Paige; for the N.Y. State Department of Public Works, C.E. Billion, Jean K. Boek, Eugene C. Cross, Jr., and Marvin M. Schwartz; and for the Department of Health, Dr. William G. Beadenkopf, Dr. Walter E. Boek, Adele Polan and Arthur S. Kraus. The study was conducted under the general supervision of B. A. Lefeve, presently New York State's Deputy Chief Engineer for Highways, and Dr. Robert F. Korns, Assistant Commissioner for program development and evaluation, Department of Health.

The principal members of the Department of Public Works field staff for the project consisted of: C. E. Billion, supervisor; Jean K. Boek, field director; Eugene C. Cross, Jr., project engineer; Marvin M. Schwartz, statistician; Edwin D. Lawson, and Phyllis P. Macauley, interviewers.

Technical advice and assistance were contributed by Dr. William G. Beadenkopf, Walter E. Boek, Adele Polan, and Arthur S. Kraus of the N.Y. State Health Department.

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Study data were punched on cards by Edwin F. Hanford and the tabulating machine staff in the Department of Public Works. Tabulations were handled by Andrew J. Pinkerton and his machine tabulation unit in the Health Department. Both men deserve particular credit for the painstaking care and accuracy with which they carried on these operations.

Special appreciation is due the following city officials of Schenectady and Scotia for the manner in which they received and helped the field staff: Archibald C. Wemple, former Mayor of Schenectady; Samuel Stratton, Mayor of Schenectady; Arthur Blessing, City Manager; William F. Brandt, Chief of Police Department; Dr. Malcolm A. Bouten, Commissioner of Health; Clarence C. Bailey, Traffic Engineer; William M. Turnbull, Mayor of Scotia; John Quinlan, Chief of Scotia Police Department.

Appreciation for help and assistance from many other Bureau of Public Roads, state and city officials, too numerous to mention, is acknowledged and finally particular thanks is due the 810 Schenectady drivers who gave their time and careful thought to the interviews and who for the most part were willing to keep diaries of the miles they drove each day. Another 757 householders kindly provided basic information by which the sample could be evaluated. The 550 persons who were observed as they drove also provided important data, although at the time it was unknown to them.

Appendix A—Comparison and Analysis of Data

COMPARISON OF SELECTED DATA

Estimated vs Observed Speed

The respondents' answers to the question of usual speed on the open road with no speed control zones were tested by comparing their estimates of speed with actual observations. Figure 6 shows the comparison of actual speeds of passenger cars on a divided 4-lane high-speed interstate highway, a divided 4-lane intercity highway, and a 2-lane primary highway, respectively, near Schenectady with the estimates of the usual speed on the open road.

If the respondents were thinking about 2-lane highways when answering the question, their estimates appear to have been very accurate. However, if they were thinking about 4-lane divided highways, they were rather conservative, as the estimated speed accumulation curve is about 7 mph, or 15 percent lower than an average of the 4-lane divided highway speed curves throughout the percentile range.

Night Driving vs Wearing Sunglasses

The hypothesis that drivers who object to driving at night usually wear sunglasses on sunny days (weak eyesight), was tested by comparing the answers to the following questions:

1. Do you usually wear sunglasses when you drive on sunny days?
2. Do you object to night driving?

Table 16 shows that a greater proportion (60 percent) of the drivers who objected to night driving usually do not wear sunglasses, than those who usually wear sunglasses (40 percent). These data reached a 95 percent confidence level.

Age vs Objection to Night Driving

The age groups of drivers were compared with those who objected to night driving.

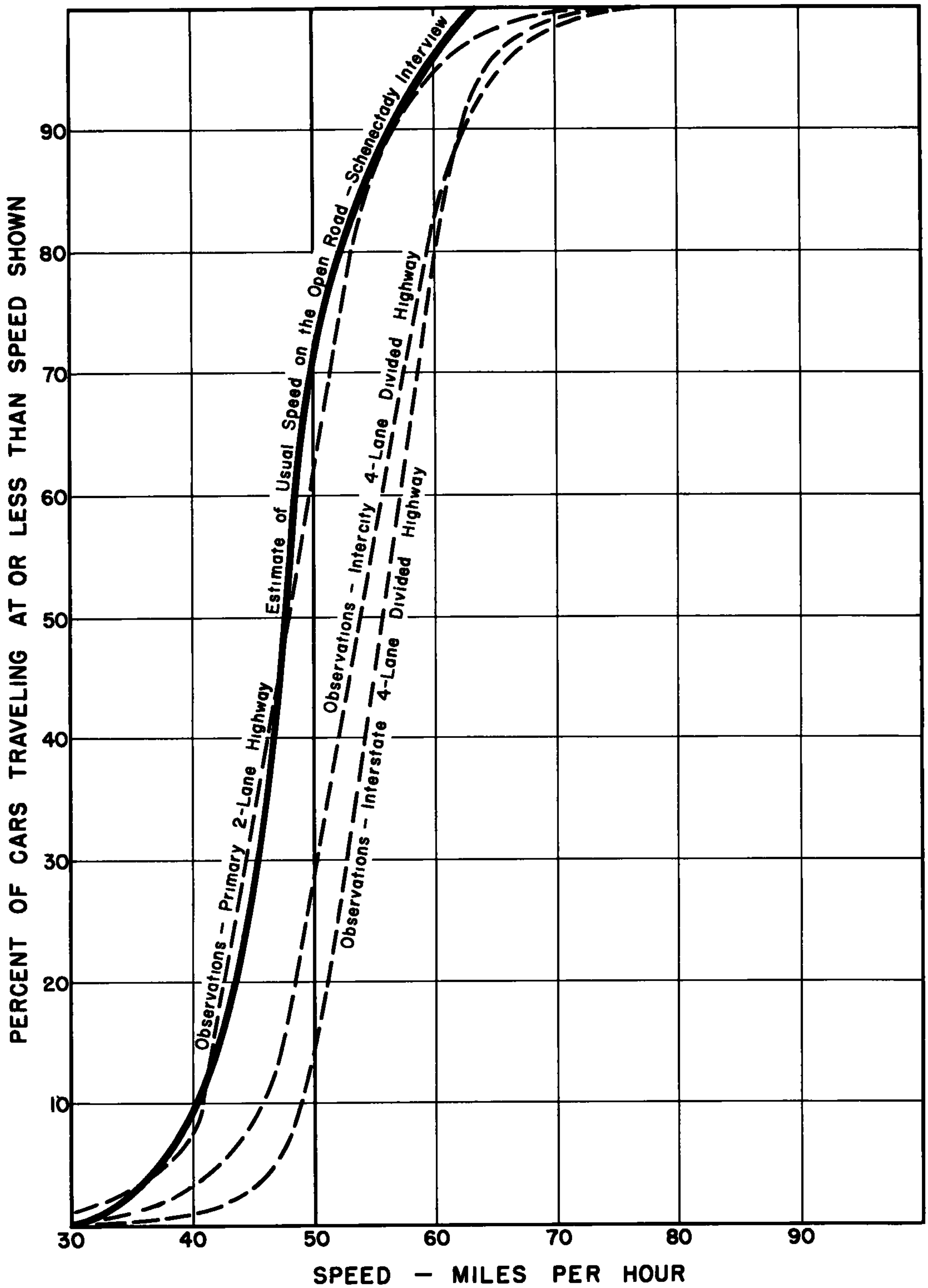

Figure 6. Comparison of speed accumulation curves for actual observations of cars with estimate of usual speed on the open road.

TABLE 16

NIGHT DRIVING VS WEARING OF SUNGLASSES WHILE DRIVING ON SUNNY DAYS

Night Driving	Sunglasses				Total	
	Usually Wear		Usually Don't Wear			
	No.	%	No.	%	No.	%
Object	55	40	83	60	138	100
Don't Object	271	44	342	56	613	100
Total	326	43	425	57	751[a]	100

[a] Gave no specific answer.

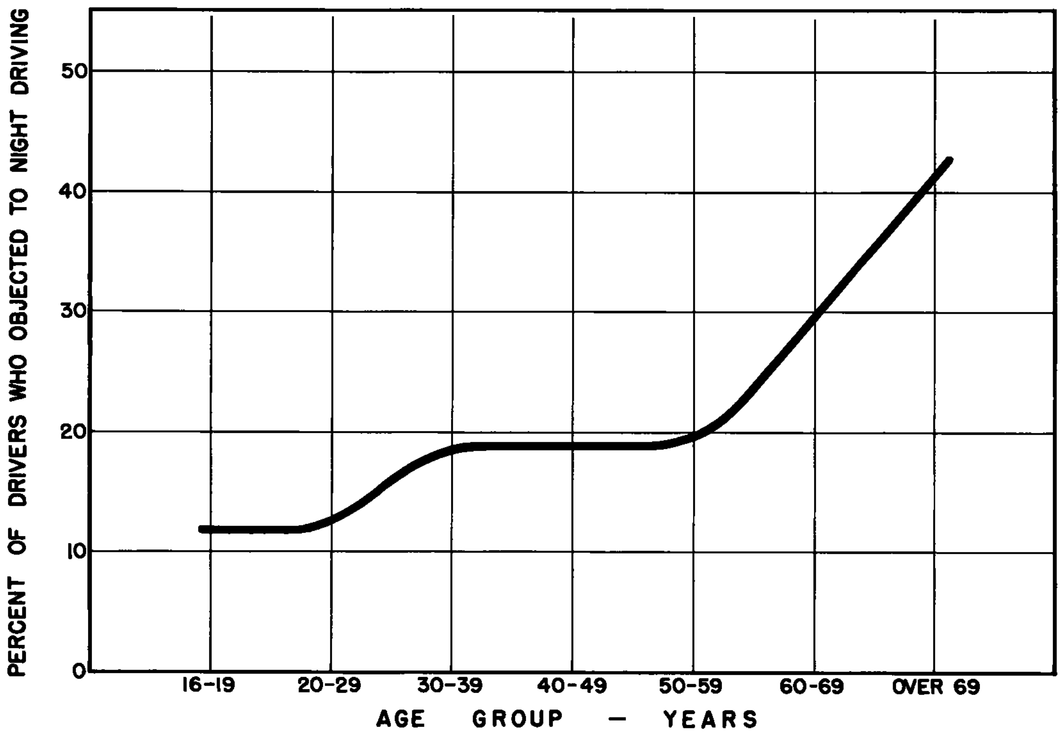

Figure 7. Percent of drivers who objected to night driving by age groups.

Table 17 shows the data broken down by age groups for those drivers who answered "yes" or "no" to the first question.

The youngest drivers (ages under 30) objected the least to night driving. The drivers from 30 to 60 years of age objected slightly more than the youngest drivers and the drivers 60 years of age and over objected the most to night driving. It is interesting to note that there is practically no difference in objection to night driving among the drivers from 30 to 60 years of age (Figure 7). These data reached a 95 percent confidence level.

Trouble Getting to Sleep vs Getting Sleepy at the Wheel

The trouble drivers had getting to sleep was compared to those drivers who did and did not get sleepy at the wheel while driving by relating the answers to the following questions:

TABLE 17

OBJECTION TO NIGHT DRIVING BY AGE GROUPS

Age of Driver	Object to Night Driving				Total	%
	Yes	%	No	%		
16 - 20	2	12	15	88	17	100
20 - 29	21	12	149	88	170	100
30 - 39	36	19	151	81	187	100
40 - 49	36	18	160	82	196	100
50 - 59	19	19	83	81	102	100
60 - 69	21	30	49	70	70	100
Over 69	7	41	10	59	17	100
Total	142	19	617	81	759[a]	100

[a] 51 gave no answer.

TABLE 18

TROUBLE GETTING TO SLEEP VS GETTING SLEEPY AT THE WHEEL WHILE DRIVING

Have Trouble Getting to Sleep	Get Sleepy While Driving				Total	%
	Yes	%	No	%		
Yes	42	47	47	52	89	100
No	387	54	333	46	720	100
Total	429	53	380	47	809[a]	100

[a] One with no answer.

1. Do you have trouble getting to sleep?
2. What do you do to wake up when you get sleepy at the wheel?

Those drivers who mentioned specific techniques to wake themselves up at the wheel were considered as those who get sleepy while driving. Table 18 shows the data for the answers to the two questions.

From these data there does not appear to be any distinct relation between a person's ease of getting to sleep at night and sleepiness while driving. This could be expected, as sleepiness while driving may be induced by causes other than physical and mental exhaustion and/or habit, such as the monotony experienced when driving fairly long distances on familiar highways requiring little physical or mental activity.

ANALYSIS OF DISTRIBUTION OF ANSWERS

The purpose of this analysis is to detect trends in the distribution of the answers for the various variables studied. Even if not of sufficient weight to be considered statistically significant, trends from the average characteristics may be of importance in studying drivers.

Procedure

The distribution of the answers for each variable selected for factor analysis (Table 9) was examined to determine the existence of trends in the data. The members of each sex were divided into low, medium, and high exposure groups so as to make each group equal in reliability.

Within each exposure group the respondents were categorized into three accident

TABLE 19

SCHENECTADY INTERVIEWED DRIVERS

Table A-4-1 Usual speed of male drivers on the open road with no speed control zones compared with exposure (miles driven) and accident status for the period from January 1, 1953 through June 30, 1955

Range of exposure - miles	0-13,085							13,107-22,879						
Average 2½ years exposure - miles	7,170							17,342						
Average yearly exposure - miles	2,868							6,937						
	Low							Medium						
	No Accident		Accident Involved				Total	No Accident		Accident Involved				Total
			Responsible		Not Responsible					Responsible		Not Responsible		
CODE	Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd		Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd	
1 Under 24 4 mph	3	3	0	0	0	0	3	0	0	0	0	0	0	0
2 24 5 - 37 4 mph	4	4	1	1	0	0	5	1	1	0	0	0	0	1
3 37 5 - 42 4 mph	22	21	2	3	1	1	25	10	9	1	1	0	1	11
4 42 5 - 47 4 mph	27	24	2	4	0	1	29	16	16	3	2	1	2	20
5 47 5 - 52 4 mph	63	68	12	10	6	3	81	60	61	8	8	8	7	76
6 52 5 - 57 4 mph	20	18	1	3	1	1	22	19	19	2	3	3	2	24
7 57 5 - 62 4 mph	10	13	5	2	0	1	15	16	18	3	2	3	2	22
8 62 5 mph and over	1	1	0	0	0	0	1	8	7	1	1	0	1	9
9 Not stated	5	4	0	1	0	0	5	1	1	0	0	0	0	1
Totals	155	156	23	24	8	7	186	131	132	18	17	15	15	164

Range of exposure - miles	22,921-161,644							0-161,644						
Average 2½ years exposure - miles	40,312							21,431						
Average yearly exposure - miles	16,125							8,572						
	High							Totals						
	No Accident		Accident Involved				Total	No Accident		Accident Involved				Total
			Responsible		Not Responsible					Responsible		Not Responsible		
CODE	Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd		Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd	
1 Under 24 4 mph	1	1	0	0	0	0	1	4	3	0	0	0	0	4
2 24 5 - 37 4 mph	0	0	0	0	0	0	0	5	5	1	1	0	0	6
3 37 5 - 42 4 mph	10	9	1	2	0	0	11	42	38	4	6	1	3	47
4 42 5 - 47 4 mph	15	14	2	3	0	1	17	58	54	7	8	1	4	66
5 47 5 - 52 4 mph	53	57	14	10	3	3	70	176	185	34	29	17	13	227
6 52 5 - 57 4 mph	26	24	3	4	1	1	30	65	62	6	10	5	4	76
7 57 5 - 62 4 mph	27	27	4	5	2	1	33	53	57	12	9	5	4	70
8 62 5 mph and over	10	10	1	2	1	0	12	19	18	2	3	1	1	22
9 Not stated	1	2	1	0	0	0	2	7	7	1	1	0	0	8
Totals	143	144	26	26	7	6	176	429	429	67	67	30	29	526

status groups for the period under study, as follows: (a) no accident, (b) accident responsible, and (c) accident not-responsible. Two sets of tables were compiled for each variable by sex.

The first set shows for each group the observed number of answers for each response and the mathematical expectation for each response, based on the assumption that the distributions for the three accident status groups are similar. Tables 19 and 20 illustrate this type of compilation. The "expected" number is required for the statistical test of significance (X^2), and when used as a comparison with the actual frequency indicates relative divergence in the distribution.

The second set shows for each group the observed number of answers and the percent of total responses, for each response. Tables 21 and 22 illustrate this type of compilation.

Examination of the data shows that there are only 67 and 30 male and 15 and 17 female drivers, respectively, in the accident responsible and accident not-responsible groups. Moreover, they are distributed among three exposure groups. Analysis based on so few observations would be unreliable. Consequently, the following analysis is for male and female drivers simply by exposure, using the distribution of the total responses in each exposure group (Tables 21 and 22).

For the male drivers, the average yearly exposure for the low, medium, and high groups was approximately 2,900, 6,900 and 16,000 mi, respectively; for the female drivers they were approximately 1,400, 3,500 and 7,900 mi, respectively.

Tables 23, 24, and 25 are examples of further information developed from the study. Table 23 indicates the accident involvement rates for the various exposure groups. Although the sample was small, definite trends in involvement and responsible involvement rates for both sexes indicate lower rates for the drivers in higher exposure groups.

In Table 24, 77 percent of the male drivers, who were "self-taught," were accident-free as compared to 88 percent accident-free for those taught by parents.

Table 25 shows male drivers with accidents in the low, medium, and high exposure groups to be 18, 16, and 20 percent, respectively. The percentage of female drivers with accidents seems to increase with exposure, being 6 percent in the low, 9 percent in the medium, and 14 percent in the high exposure group.

TRENDS FROM OTHER TABLES

Male Drivers

From tables not included with this paper, the following observations are made:

1. Size of household. No notable trend in size of household from one exposure group to another. The average size of household in all exposure groups was 3.

2. Age of respondent. In the low exposure group the average age was 45; in the medium group, 41; in the high group, 39.

3. Years of driving experience. The average member in the low group had 24 years of experience. In the medium group the average was 20; in the high, 24.

4. Year of car driven. In the low group the average car driven was a 1951 model. In the medium and high groups it was a 1952 model.

TABLE 20

SCHENECTADY INTERVIEWED DRIVERS

Table A-5-1 Usual speed of female drivers on the open road with no speed control zones compared with exposure (miles driven) and accident status for the period from January 1, 1953 through June 30, 1955

Range of exposure - miles	0-6,810							6,915-11,756						
Average 2½ years exposure - miles	3,777							8,685						
Average yearly exposure - miles	1,351							3,474						
	Low							Medium						
CODE	No Accident		Accident Involved Responsible		Not Responsible		Total	No Accident		Accident Involved Responsible		Not Responsible		Total
	Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd		Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd	
0 Do not drive on open road	7	7	0	0	0	0	7	1	1	0	0	0	0	1
1 Under 32 4 mph	5	6	1	0	0	0	6	0	0	0	0	0	0	0
2 32 5 - 37 4 mph	7	7	0	0	0	0	7	0	0	0	0	0	0	0
3 37 5 - 42 4 mph	25	27	3	1	0	0	28	5	6	2	1	0	1	7
4 42 5 - 47 4 mph	40	39	1	2	0	0	41	5	4		0	0	0	5
5 47 5 - 52 4 mph	52	51	2	3	0	0	54	24	23	1	2	2	2	27
6 52 5 - 57 4 mph	10	10	1	1	0	0	11	5	6	1	1	1	1	7
7 57 5 - 62 4 mph	8	8	0	0	0	0	8	3	3	0	0	1	0	4
8 62 5 mph & over	2	2	0	0	0	0	2	0		0	0	0	0	0
9 Not stated	2	2	0	0	0	0	2	2	2	0	0	0	0	2
X Depends on road, not on speed control	0	0	0	0	0	0	0	1	1		0	0	0	1
Totals	158	159	8	7	0	0	166	46	46	4	4	4	4	54

Range of exposure - miles	11,808-40,814							0-40,814						
Average 2½ years exposure - miles	19,817							7,647						
Average yearly exposure - miles	7,927							3,059						
	High							Totals						
CODE	No Accidents		Accident Involved Responsible		Not Responsible		Total	No Accident		Accident Involved Responsible		Not Responsible		Total
	Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd		Obs'd	Expt'd	Obs'd	Expt'd	Obs'd	Expt'd	
0 Do not drive on open road	0	0	0	0	0	0	0	8	7	0	0	0	0	8
1 Under 32 4 mph	0	0	0	0	0	0	0	5	6	1	0	0	0	6
2 32 5 - 37 4 mph	0	0	0	0	0	0	0	7	6	0	0	0	0	7
3 37 5 - 42 4 mph	4	4	0	0	0	0	4	34	36	5	2	0	1	39
4 42 5 - 47 4 mph	6	5	0	0	0	0	6	51	48	1	3	0	1	52
5 47 5 - 52 4 mph	27	27	2	1	1	1	30	103	102	5	6	3	3	111
6 52 5 - 57 4 mph	9	9	0	0	1	0	10	24	26	2	1	2	1	28
7 57 5 - 62 4 mph	12	12	1	1	0	1	13	23	23	1	1	1	1	55
8 62 5 mph & over	0	1	0	0	1	0	1	2	3	0	0	1	0	3
9 Not stated	0	0	0	0	0	0	0	4	4	0	0	0	0	4
X Depends on road, not on speed control	0	0	0	0	0	0	0	1	1	0	0	0	0	1
Totals	58	58	3	2	3	2	64	262	262	15	13	7	7	284

TABLE 21

SCHENECTADY INTERVIEWED DRIVERS

Table A-6-1 Usual speed of male drivers on the open road with no speed control zones compared with exposure (miles driven) and accident status for the period from January 1, 1953 through June 30, 1955

	Low								Medium							
Range of exposure-miles	0-13,085								13,107-22,879							
Average 2½ years exposure-miles	7,170								17,342							
Average yearly exposure-miles	2,868								6,937							
	No Accident		Accident Involved: Responsible		Accident Involved: Not Responsible		Total		No Accident		Accident Involved: Responsible		Accident Involved: Not Responsible		Total	
CODE	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%
	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1 Under 24 4 mph	3	1	0	0	0	0	3	1	0	0	0	0	0	0	0	0
2 24 5 - 37 4 mph	4	3	1	4	0	0	5	3	1	1	0	0	0	0	1	1
3 37 5 - 42 4 mph	22	14	2	9	1	13	25	13	10	8	1	6	0	0	11	7
4 42 5 - 47 4 mph	27	17	2	9	0	0	29	15	16	12	3	17	1	7	20	12
5 47 5 - 52 4 mph	63	41	12	52	6	74	81	43	60	45	8	43	8	53	76	46
6 52 5 - 57 4 mph	20	13	1	4	1	13	22	12	19	15	2	11	3	20	24	15
7 57 5 - 62 4 mph	10	6	5	22	0	0	15	8	16	12	3	17	3	20	22	13
8 62 5 mph and over	1	1	0	0	0	0	1	1	8	6	1	6	0	0	9	5
9 Not stated	5	3	0	0	0	0	5	3	1	1	0	0	0	0	1	1
Totals	155	100	23	100	8	100	186	100	131	100	18	100	15	100	164	100

	High								Totals							
Range of exposure-miles	22,921-161,644								0-161,644							
Average 2½ years exposure-miles	40,312								21,431							
Average yearly exposure-miles	16,125								8,572							
	No Accident		Accident Involved: Responsible		Accident Involved: Not Responsible		Total		No Accident		Accident Involved: Responsible		Accident Involved: Not Responsible		Total	
CODE	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%
1 Under 24 4 mph	1	1	0	0	0	0	1	1	4	1	0	0	0	0	4	1
2 24 5 - 37 4 mph	0	0	0	0	0	0	0	0	5	1	1	1	0	0	6	1
3 37 5 - 42 4 mph	10	7	1	4	0	0	11	6	42	10	4	6	1	3	47	9
4 42 5 - 47 4 mph	15	10	2	8	0	0	17	10	58	14	7	10	1	3	66	13
5 47 5 - 52 4 mph	53	37	14	53	3	43	70	40	176	41	34	52	17	57	227	43
6 52 5 - 57 4 mph	26	18	3	12	1	14	30	17	65	15	6	9	5	17	76	14
7 57 5 - 62 4 mph	27	19	4	15	2	29	33	18	53	12	12	18	5	17	70	13
8 62 5 mph & over	10	7	1	4	1	14	12	7	19	4	2	3	1	3	22	4
9 Not stated	1	1	1	4	0	0	2	1	7	2	1	1	0	0	8	2
Totals	143	100	26	100	7	100	176	100	429	100	67	100	30	100	526	100

5. Instructor. There was a rather strong tendency for the high exposure group to reply "self" (49 percent vs 39 percent for an average of all).

6. Education. In the low and medium groups the average respondent had completed the 11th grade. The average male in the high exposure group graduated from high school.

7. Present marital status. Of all male drivers, 75 percent replied "married". But those in the low exposure group were below this average (67 percent), whereas those in the medium group were relatively high (82 percent).

8. Opinion of night driving. There was a small downtrend as exposure increased in the frequency of the reply "I object because of lights" (19, 17, 11 percent), whereas for the response "don't object", the trend was up as exposure increased (64, 65, 73 percent).

9. Share of worries in past three years. There is no evidence that the responses given by the interviewees differ from group to group in any indicative fashion when small values are discounted.

10. Whether respondent smokes now or has in past three years. As exposure increases, there was a slightly decreasing tendency to reply "Have not smoked in past three years" (23, 17, 15 percent). However, the exposure groups separately do not vary much from the average for all males.

11. Amount of smoking. As exposure increased there was a decreasing tendency to answer "one pack of cigarettes per day" (38, 36, 33 percent).

12. Whether or not they smoke while driving. As exposure increases, there was an upward trend for the response "yes" (47, 49, 62 percent). In the high exposure group, the response "yes" was given substantially higher than average (62 vs 53 percent). The

TABLE 22

SCHENECTADY INTERVIEWED DRIVERS

Table A-7-1 Usual speed of female drivers on the open road with no speed control zones compared with exposure (miles driven) and accident status for the period from January 1, 1953 through June 30, 1955

Range of exposure-miles	0-6,810								6,915-11,756							
Average 2½ years exposure-miles	3,777								8,685							
Average yearly exposure-miles	1,351								3,474							
	Low								Medium							
	No Accident		Accident Involved				Total		No Accident		Accident Involved				Total	
			Responsible		Not Responsible						Responsible		Not Responsible			
CODE	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%
0 Do not drive on open road	7	4	0	0	0	0	7	4	1	2	0	0	0	0	1	2
1 Under 32 4 mph	5	3	1	13	0	0	6	4	0	0	0	0	0	0	0	0
2 32 5 - 37 4 mph	7	4	0	0	0	0	7	4	0	0	0	0	0	0	0	0
3 37 5 - 42 4 mph	25	16	3	37	0	0	28	16	5	11	2	50	0	0	7	13
4 42 5 - 47 4 mph	40	26	1	13	0	0	41	25	5	11	0	0	0	0	5	9
5 47 5 - 52 4 mph	52	34	2	24	0	0	54	33	24	52	1	25	2	50	27	50
6 52 5 - 57 4 mph	10	6	1	13	0	0	11	7	5	11	1	25	1	25	7	13
7 57 5 - 62 4 mph	8	5	0	0	0	0	8	5	3	7	0	0	1	25	4	7
8 62 5 mph & over	2	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0
9 Not stated	2	1	0	0	0	0	2	1	2	4	0	0	0	0	2	4
X Depends on road, not on special control	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
Totals	158	100	8	100	0	0	166	100	46	100	4	100	4	100	54	100

Range of exposure-miles	11,808-40,814								0-40,814							
Average 2½ years exposure-miles	19,817								7,647							
Average yearly exposure-miles	7,927								3,059							
	High								Totals							
	No Accident		Accident Involved				Total		No Accident		Accident Involved				Total	
			Responsible		Not Responsible						Responsible		Not Responsible			
CODE	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%	Obs'd	%
0 Do not drive on open road	0	0	0	0	0	0	0	0	8	3	0	0	0	0	8	3
1 Under 32 4 mph	0	0	0	0	0	0	0	0	5	2	1	7	0	0	6	2
2 32 5 - 37 4 mph	0	0	0	0	0	0	0	0	7	3	0	0	0	0	7	2
3 37 5 - 42 4 mph	4	7	0	0	0	0	4	6	34	13	5	33	0	0	39	14
4 42 5 - 47 4 mph	6	10	0	0	0	0	6	9	51	19	1	7	0	0	52	18
5 47 5 - 52 4 mph	27	46	2	67	1	33	30	47	103	39	5	33	3	43	111	40
6 52 5 - 57 4 mph	9	16	0	0	1	33	10	16	24	9	2	13	2	29	28	10
7 57 5 - 62 4 mph	12	21	1	33	0	0	13	20	23	9	1	7	1	14	25	9
8 62 5 mph & over	0	0	0	0	1	33	1	2	2	1	0	0	1	14	3	1
9 Not stated	0	0	0	0	0	0	0	0	4	2	0	0	0	0	4	1
X Depends on road, not on speed control	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Totals	58	100	3	100	3	99	64	100	262	100	15	100	7	100	284	100

medium group replied "only occasionally" with moderately higher than average frequency.

13. Whether or not they drink. In the medium group "yes" was given as a response somewhat less than average (27 vs 35 percent). "Sometimes" was stated somewhat higher than average (24 vs 18 percent), as was "moderately" (15 vs 9 percent). The reverse of these trends holds for both the high and low exposure groups.

14. Whether or not they drive after drinking on occasion. As exposure increased, there was a decided tendency to reply "yes" (26, 32, 40 percent). The response "yes" was given less than average in the low group (26 vs 33 percent), and higher than average (40 vs 33 percent), and higher than average (40 vs 33 percent) by the high group. In comparison with the over-all average for the answer "no", the low exposure group had a rather high frequency (30 vs 22 percent) and the high group was low (15 percent).

15. Whether or not they wear glasses. The response, "for reading but not driving", had a slight uptrend (10, 14, 15 percent) as exposure increased. The response "yes" was somewhat below average in the high exposure group (27 vs 34 percent).

16. Whether or not they wear sunglasses while driving on sunny days. As exposure increased there was a fairly strong uptrend for the response "yes" (31, 38, 43 percent). "No" had a moderate downtrend (53, 47, 44 percent) as exposure increased.

17. Usual speed on the open road with no speed control zones. As exposure increased, there was a decreasing tendency for interviewees to answer "37. 5 to 42. 4" (13, 7, 6 percent). The same was true for the response "42. 5 to 47. 4" (15, 12, 10

TABLE 23

DRIVER ACCIDENT INVOLVEMENT RATES PER 100 MILLION VEHICLE-MILES BY SEX AND AMOUNT OF EXPOSURE

Sex	Male			Female		
Exposure group	Low	Medium	High	Low	Medium	High
Number of drivers	186	164	176	166	54	64
Number of involvements[a]	31	33	33	8	8	6
Number of responsible involvements	23	18	26	8	4	3
Average mileage[a]	7,170	17,342	40,312	3,777	8,685	19,817
Involvement rate	2,324	1,160	465	1,276	1,706	473
Responsible involvement rate	1,725	633	366	1,276	853	236

[a] Study period January 1, 1953, through June 30, 1955.

percent). However, as exposure increased there was a small consistent upward tendency for interviewees to reply "52. 5 to 57. 4" (12, 15, 17 percent). There was a large increase as exposure increased for the reply "57. 5 to 62. 4" (8, 13, 18 percent). The reply "62. 5 mph and over" also increased with exposure, but a lesser degree (1, 5, 7 percent). By far the most frequent reply for all exposure groups was "47. 5 to 52. 4", but in general the rate of speed increased with exposure.

18. Opinion of own driving skill. As exposure increased, the males showed an increasing tendency to reply "above average" (11, 15, 20 percent). Other trends and divergences from average were trivial.

19. Relative ease in finding their way on a strange road. As exposure increased, male interviewees had an increasing tendency to reply "easy" (40, 43, 51 percent). Other trends and divergences from average were negligible.

TABLE 24

PERCENT OF MALE DRIVERS WHO WERE ACCIDENT-FREE BY TYPE OF DRIVING INSTRUCTOR

Instructor	Exposure range							
	Low		Medium		High		Total	
	Number of drivers	Percent accident free	Number of drivers	Percent accident free	Number of drivers	Percent accident free	Number of drivers	Percent accident free
Parent	30	90	30	87	27	89	87	88
Relative	30	93	25	80	21	81	76	86
Friend	41	85	40	80	32	84	113	83
Self	63	76	53	75	87	79	203	77
Other	22	77	16	81	9	67	47	77

TABLE 25

ACCIDENT EXPERIENCE OF DRIVERS SEPARATED EQUALLY BY EXPOSURE RANGES

Sex	Low mileage 0-7,600				Medium mileage 7,601-18,000				High mileage 18,001-161,000			
	Number of drivers	Number accident free	Percent no accident	Percent accident	Number of drivers	Number accident free	Percent no accident	Percent accident	Number of drivers	Number accident free	Percent no accident	Percent accident
Male	90	74	82	18	194	162	84	16	242	193	80	20
Female	180	169	94	6	76	69	91	9	28	24	86	14
Total	270	243	90	10	270	231	86	14	270	217	80	20

Female Drivers

1. Size of household. The size of the average household was three for the low and medium group, but two for the high exposure group.

2. Age. In the low exposure group the average age of female drivers was 35. It was 37 for the medium group, and 36 for the high exposure group.

3. Years of experience. In the low exposure group, the average female driver had 5 years of driving experience. The average for the medium group was 13 years; for the high, 15 years. There is a strong tendency for females with relatively little experience to do relatively little driving.

4. Year of vehicle driven. The average age of vehicles driven was the same (4 years) for all three exposure groups.

5. Instructor. As exposure increased, there was a moderate downtrend in the frequency with which the females replied "commercial school" (11, 7, 0 percent). The medium exposure group, compared with females as a whole, had a high frequency for the response "parent" (22 vs 13 percent), and was low for the response "relative" (26 vs 36 percent).

6. Education. The medium exposure group of females responded "college graduate" somewhat above average (19 vs 12 percent), but the average female in all groups was a high school graduate.

7. Marital status. As exposure increased, there was a strong downtrend in the frequency of the reply "married" (72, 69, 50 percent). The frequency of the response "married" in the high exposure group was well below the average for all females (50 vs 67 percent).

8. Labor force status. As exposure increased, there was a considerable increase for the response "employed" (31, 35, 63 percent). Likewise, there was a strong downtrend for the reply "housewife" (60, 59, 27 percent). The high group was much above average with respect to the response "employed" (63 vs 39 percent), and considerably below average for the response "housewife" (27 vs 52 percent).

9. Opinion of night driving. As exposure increased, the frequency of the response "don't object" sharply rose (61, 63, 80 percent). The occurrence of this response in the high group was relatively high in relation to that for all females (80 vs 66 percent).

10. Smoking now or in the past three years. No trends were found in the frequency of responses made, nor any but trivial divergences from average on the part of the various exposure groups.

11. Amount of smoking now. The responses to this question showed only slight trends and divergences from average. It may be noted that 51 percent of all females replied "I do not smoke now."

12. Wearing of sunglasses while driving on sunny days. The reply "no" was given decreasingly as the exposure increased, (40, 28, 27 percent). Those in the medium exposure group replied "yes" appreciably higher than average (61 vs 52 percent).

13. Usual speed on open road with no speed control zones. In all exposure groups, the speed group most often claimed was "47.5 to 52.4."

14. Opinion of driving skill. As exposure increased there was a moderate increase in the frequency of the reply "experienced" (19, 30, 34 percent). The trend of decreasing responses of "average to fair" as exposure increased was quite strong (51, 48, 31 percent). In comparison to females as a whole, the high group had a high frequency for the reply "experienced" (34 vs 24 percent). However, the relative frequency in the high group for the "average to fair" response was very low (31 vs 46 percent).

15. Interviewees own opinion as to being slow or fast driver. As exposure increased there was a moderate consistent increase for the response "fast" (7, 9, 19 percent). The medium exposure group of females fell considerably below the average in the frequency with which they responded "slow" (13 vs 29 percent), but were somewhat above average for the reply "average" (69 vs 57 percent).

16. Relative ease of finding way on strange roads. As exposure increased there was a large increase in the frequency of the response "easy" (26, 33, 52 percent). But the trend of the reply "difficult" was large downward as exposure increased (49, 26, 22 percent). Compared to the average frequency, the high group had a large frequency for the reply "easy" (52 vs 33 percent), whereas the reply "difficult" was low (22 vs 38 percent).

17. Opinion as to whether traffic laws are enforced strictly enough. The response "no" was given somewhat below average by the female interviewees in the medium group (24 vs 32 percent), but above average in the high group (41 vs 32 percent).

Appendix B—Interview and Report Forms

NEW YORK STATE

COOPERATIVE RESEARCH PROJECT

Driver Behavior and Highway Safety Research

Department of Public Works
Department of Health
United States Bureau of Public Roads

August, 1955
Draft 5
SA #3

Schedule for Schenectady Sample

Hello. My name is . . . . I'm from the Department of Public Works which together with the Health Department is carrying on this special study. We are trying to learn more about people and their driving in order that better highways can be planned. Would you mind helping us by answering some questions related to your driving?

Code Card I

Random Start in Household________

Edited by________

Coded by________

Blank	1.	________
Schedule Number	2-5.	1456
Card Number	6-8.	________
Block Number	9.	________
Household Number	10.	________
Interviewer ________	11.	________
Address________	12.	________
________	13.	________
Record of visits:	14.	________

Visit	Date	Day of Week	Time	Comment
1				
2				
3				
4				

Schenectady Sample
Card I

First of all, we need to know how many persons including yourself live in your immediate household?__________ 15______

16______

What are their names? (Interviewer: Put answers on chart. After you get a list of names, check off male or female and ask for each person:)

When was........born? 17______

For those 16 years of age and over: 18______

Has.........ever driven a car or other motor vehicle since January 1953? 19______
(Now number drivers from oldest to youngest. Number one is oldest driver.)

20______

Random start for household__________

21______

Names	M	F	Birth Date	Driven since Jan. 1953 Yes	Driven since Jan. 1953 No	Number of Drivers Oldest to Youngest	x R. S. D.

22______
23______
24______
25______
26______
27______
28______
29______
30______
31______
32______
33______
34______
35______

(Interviewer: If no one in the household has driven since January 1953, thank them for the interview and leave. If respondent has not driven but others in the household have, or if respondent drives but is not in the random start, ask if it is possible to continue your visit with the driver selected by your random start: "In this study we need to talk with only a sample of drivers. I wonder if I might talk with........?" 36______ 37______

Schenectady Sample

Card I

38 ______

39 ______

40-41 ______

42 ______

43 ______

44-47 ______

(For introduction to random start driver if you have not seen him or her before.) My name is . . . . (Miss, Mr., Mrs.) . . . . . I'm from the Department of Public Works, which together with the Health Department is carrying on a special study. Very little is known about how much people drive. In order to plan highways we need to obtain this information directly from people who do the driving.

To begin with, we wondered when you first drove a car? ________________

(Put replies to next questions in chart below.)

What kind of a car or cars do you drive now?
What year was it made?
Are you the owner? (A car owned by husband is also considered to be owned by the wife. A family car is not owned by sons or daughters.)

What is the month and year you started driving this car(these cars)?
What was the speedometer reading when you started driving it?
What is the speedometer reading now?
What percentage of that mileage did you drive?

$\frac{\text{SR Now} - \text{SR Beg.} \times \%}{\text{Months Driven}}$ = Av. Mi/Mo.

How many cars and commercial vehicles are owned altogether in this household now?__________

______ - ______ X ______ =

Car Driven	Car Year	Own		Date Started Driving		Speedometer Reading Beginning	Speedometer Reading Now	% Driven by R. Start
		Yes	No	Month	Year			
Buick	19___							
Chevrolet	19___							
Chrysler	19___							
DeSoto	19___							
Dodge	19___							
Ford	19___							
Hudson	19___							
Nash	19___							
Oldsmobile	19___							
Plymouth	19___							
Pontiac	19___							
Studebaker	19___							
Truck or Comm. Vehicle	19___							
Other______ ______	19___ 19___							

Schenectady Schedule
Card I

(Interviewer: We need a record of cars driven since January 1953. Repeat these questions until you can record all cars since then. Put all replies for cars prior to present on the chart below.) 48-49____ 50____ 51____

What kind of car or cars did you drive before this one since the beginning of 1953? 52-55____

For each one: 56-57____
What year was it made? 58____
What is the month and year you started driving the car?
What was the speedometer reading when you began driving it? 59-62____
What percentage of this mileage did you drive? 63____
Did you drive any trucks or cars with commercial licenses since that time? (1)Yes___ (2)No___ 64-65____ 66____
If yes: Ask the same list of questions and put answers on chart.

$$\frac{SR(end) - SR(beg.) \times \%}{\text{Months driven}} = \text{Ave. mi/mo.}$$

____ - ____ X ____ = ____

Car Driven	Car Year	Date Began Driving Car month	year	Date Stopped Driving Car month	year	Speedomtr Reading Beginning	Speedomtr Reading End	% Driven by R.S.D.
Buick	19____ 19____							
Chevrolet	19____ 19____							
Chrysler	19____ 19____							
DeSoto	19____ 19____							
Dodge	19____ 19____							
Ford	19____ 19____							
Hudson	19____ 19____							
Nash	19____ 19____							
Oldsmobile	19____ 19____							
Plymouth	19____ 19____							
Pontiac	19____ 19____							
Studebaker	19____ 19____							
Truck or Commercial Vehicle	19____ 19____							
Other	19____ 19____							

67-70____
71-72____
73____
74-77____
78____
79____
80____

Card II

1____
2-5____
6 2
7-8____
9____
10-13____
14-15____
16____
17-20____
21____
22-23____
24____
25-28____
29____

Schenectady Sample

Did you drive yesterday? (1) Yes____ (2) No____ Card II

Comment ____ 30________

(Write day of week:____________) 31________

If No: When was the last time you did any driving?____________ 32________

What day of the week was it? ____________ 33________

What trips did you make that day? 34________

(Definition of trip: "When you get in a car, it begins a trip, and when you have to get out of your car, that ends one.") 35________

36________

(Interviewer: Put each trip separately on the chart.)

Trip	From	To	Miles	EW	RT
1					
2					
3					
4					
5					
6					
	Interviewer Calculation Total				

37________
38________
39________
40________
41________
42________
43________
44________
45________
46________
47________
48________

What time did you begin and end the first trip?

Time begun:____A.M. ____P.M. Time ended: ____A.M. ____P.M.

What route or street did you take for the first trip?

____

____

____

Schenectady Sample

What time did you begin and end the second trip? Card II

Time begun: _____A.M. _____P.M. Time ended:_____A.M. _____P.M. 49_______

What route or street did you take for the second trip? 50_______

____ 51_______

52_______

____ 53_______

____ 54_______

55_______

____ 56_______

What time did you begin and end the third trip?

57_______

Time begun: _____A.M. _____P.M. Time ended: _____A.M. _____P.M.

58_______

What route or street did you take for the third trip?

59_______

____ 60_______

____ 61-62_______

63-65_______

____ 66-69_______

____

What time did you begin and end the fourth trip?

Time begun: _____A.M. _____P.M. Time ended: _____A.M. _____P.M.

What route or street did you take for the fourth trip?

____

____

____

____

Schenectady Sample

Card II

What time did you begin and end the fifth trip?

Time begun: _____ A.M. _____ P.M. Time ended: _____ A.M. _____ P.M.

What route or street did you take for the fifth trip?

____

____

____

____

What time did you begin and end the sixth trip?

Time begun: _____ A.M. _____ P.M. Time ended : _____ A.M. _____ P.M.

What route or street did you take for the sixth trip?

____

____

____

____

Who was your instructor when you were learning to drive? 70_____

(1) Friend_____ (2) Parent_____ (3) Relative_____ (4) Self_____

(5) High School_____ (6) Commercial School _____

Other ____
specify

How many times did you take the exam for your first license? 71_____

(1) Once_____ (2) Twice_____ (3) Three Times _____ (0) Never took one_____

Other ____
specify

Schenectady Schedule
Card II

What is the highest grade or year in school that you completed?____________ 72______

What is your present marital status? (1)Single___(2)Married___Other________

____ 73 ______

Have you ever been widowed, separated, or divorced? (1)Yes____(2)No___ 74______

If yes: which of these was it? (3)Widowed___(4)Separated___(5)Divorced___

What kind of work do you do? Housework____Other____________________ 75 ______

____
specify

Are you employed at present?

(1)Yes____(2)Housework____(3)Retired___(4)Too ill to work___

(5)Temporary layoff____Other______________________________ 76______
specify

If employed: Where do you work?

(1)G.E.______Other___________________________________ 77______
specify

If retired, ill, or temporary layoff: Where did you work?

(1) G.E.______Other__________________________________ 78______

Now thinking back from January through June of this year, what kind of work did you do during that period?

(1)Same as now_____Other______________________________ 79______
specify

Where did you live then? (1)Here_____Other____________________
Street and City

____ 80______
Street and City

Did you drive back and forth to work during the first half of this year?

Card III

(1)Yes___(2)No___Other________________________________ 1______
specify

If yes: How many miles was it each day?____________ 2-5______

How many days a week did you drive?____________ 6 3

How many weeks in the six months period did you drive back and forth to work?____________ 7______

If reply is "all weeks", ask: Was any vacation or other time taken during this period? (1)Yes___(2)No___Other__________ 8______
specify

____

If yes: How many weeks?_______________

9-12______

Editing Calculation : (_____________________________________ __________________)
(Miles RT X days/week X weeks in 6 months = Total to and from work)

Schenectady Sample

Card III

Did you drive as part of your job from January through June of this year?

(1) Yes_____ (2) No_____ Other______________________________
specify

If Yes: How many miles did you travel each week on the job?___ ________

How many weeks did you drive on the job for the six months?______

(Editing ______________ = ______________)
(Calculation: Miles/week X Weeks/6 mos. = Miles on the Job) 13-16________

Did you drive on any vacations or long trips up through June?

(1) Yes_____ (2) No_____ Other______________________________
specify

If Yes: How many miles did you drive? ______________________
(Write out places traveled to and number of times only if miles unknown.)

Destination	Mileage	Number of times

17-20________

(Editing ______________ = ______________)
(Calculation: Miles / Trip X No. of trips = Miles on Vacation)

Did you drive on weekend or day trips up through June?

(1) Yes_____ (2) No_____ Other____________________

If Yes: On how many trips did you drive?________________

Where did you go?

(Interviewer: List places on the chart. Only if places are unknown to you or unlikely to be on a map, should you ask for the mileage. Other mileages can be secured by plotting on a map during editing.)

Destination	Mileage	Number of times

21-24________

(Editing

Schenectady Sample
Card III

Did you drive for evening trips or visiting during the first six months of this year?

(1)Yes_____(2)No_____Other_______________________________
specify

If yes: How many trips a month did you average?_______________ 25-28 ________

How many miles did you average on each trip?___________

Editing Calculation = {_______________ (Trips/month X 6 X Average miles/trip = Total for evening or visiting}

Did you drive for shopping or other purposes during the first half of 1955?

(1)Yes_____(2)No_____Other_______________________________
specify

If yes: How many trips a week did you average?___________

How many miles did you average for each trip?___________

Is there any other driving you have done from January through June that I have missed?

(1)Yes_____(2)No_____Other_______________________________
specify

If yes: About how many miles would this be?_______________

(Interviewer: Calculate these miles in with miles driven for shopping and other purposes.

Calculation: _______________ Trips/week X Miles/trip X 26 , other driving = Total for shopping and other purposes 29-32________

Interviewer Calculation Summary for 1955

Type of travel	Schedule Page	Miles
To and from work	8	
On the job	9	
Vacations and long trips	9	
Weekend and day trips	9	
Evening and visiting	10	
Shopping and other purposes	10	
Total		

33-37________

38________

39________

Schenectady Sample

Card III

For the purposes of this study we need to know how many miles you drove altogether in 1954:________________

Now, going back to the whole year of 1954, where did you live during that year?

(1) Here_____ Other____ 40________
Street and City

Where did you work that year? (1) Same as now_____ Other________________ 41________
specify

Did you drive back and forth to work during 1954?

(1) Yes_____ (2) No_____ Other_________________________________
specify

If Yes: How many miles was it each day?_________

How many days a week did you drive?_________

How many weeks in the 12 month period did you drive back and forth to work?_________

If reply is "all weeks" ask: Was any vacation or other time taken during his period?

(1)Yes_____ (2)No_____ Other______________________________
specify

(Editing ______________ ______________ = ______________) 42-46________
(Calculation: Miles RT x days/wk. X weeks worked = Total to and from work)

Did you drive as part of your job during 1954?

(1)Yes_____ (2) No_____ Other____________________________________
specify

If Yes: How many miles did you travel each week on the job?____________

How many weeks did you drive this during 1954?________________

(Editing ______________ = ______________)
(Calculation : Miles /week X weeks/12 mos. = Miles on the job) 47-51________

Did you drive on any vacations or long trips that year?

(1) Yes_____ (2) No_____ Other__________________________________
specify

Schenectady Sample

Card III

If Yes: How many miles did you drive on vacation. (Write out places traveled to and number of times only if miles unknown by by respondent.)

Destination	Mileage	Number of times

(Editing ______________ = ______________)
(Calculation: Miles/trip X No. of trips = Miles on Vacation) 52-56________

Did you drive on weekend or day trips any time during the year?

(1) Yes______ (2) No______ Other______________________________
specify

If Yes: On how many trips did you drive?______________

Where did you go?

(Interviewer: List places on the chart. Only if places are unknown or unlikely to be on a map, should you ask for the mileage. Other mileages can be secured by plotting on a map during editing.)

Destination	Mileage	Number of times

(Editing ______________ = ______________)
(Calculation: Number of miles X number of times = Weekend and day trips) 57-61________

Did you drive for evening trips or visiting during the year, 1954?

(1) Yes______ (2) No______ Other______________________________
specify

If Yes: How many trips a month did you average?____________

How many miles did you average on each trip?________ 62-66________

(Editing ______________ = ______________)
(Calculation: Trips/month X 12 X Average miles/trip = Total for evening and visiting)

Schenectady Sample
Card III

Did you drive for shopping or other purposes during 1954?

(1) Yes_____ (2) No_____ Other ______________________________
specify

If Yes: How many trips a week did you average?_________

How many miles did you average for each trip?_________

Was there any driving you did during 1954 that we may have missed?

(1) Yes _____ (2) No_____ Other ______________________________
specify

If Yes: How many miles was this? ____________ 67-70________

(Editing ____ = ____________)
(Calculation: Trips/week X Miles/trip X 52 + other miles = Total for other purposes)

Interviewer Calculation Summary for 1954

Type of Travel	Schedule page	Miles
To and from work	11	
On the job	11	
Vacations and long trips	12	
Weekend and day trips	12	
Evening and visiting	12	
Shopping and other purposes	13	
Total Calculated		
Total Estimated	11	

71-75________

76-80________

Schenectady Sample
Card IV

We need just a little more information on your driving in 1953. 1______

First of all, where did you live from January to December of that year? 2-5______ 6 4

(1)Here_____(2)Other______________________________ 7______
Street and City

Where did you work in 1953? (1)Same as now_____Other_________________ 8______

____
specify

Did you drive back and forth to work during that year?
(1)Yes_____(2)No_____Other____________________________
specify

Did you take vacation or other long trips that year?
(1)Yes_____(2)No_____Other____________________________
specify

How much more or how much less did you drive in 1953 than in 1954?

(1)Same_____(2)More____________(3)Less____________Other____________
No. of miles No. of miles

____
specify

Editing Calculation : 1954____________miles 9-13______
1953____________miles

Now (Mr., Mrs., Miss....), most people's driving is affected by the way they feel. What are your feelings when you take the wheel to drive?

____ 14-15______

____

In general, do you enjoy driving or not? 16______

(1)Enjoy_____(2)Don't enjoy_____Comment____________________
specify

____

Schenectady Sample

Card IV

Do you object to driving at night or not?

(1) Object_____ (2) Don't object_____ Comment_________________________ 17_______
specify

____

Are you satisfied or dissatisfied with the mechanical performance and the way your car drives?

(1) Satisfied_____ (2) Dissatisfied_____ Comment_________________________ 18_______
specify

____

Why do you feel this way?____ 19-20_______

____

Are you satisfied or dissatisfied with the appearance of the car you drive?

(1)Satisfied_____(2) Dissatisfied_____ Comment_________________________ 21_______
specify

____

What are your reasons?____ 22,23_______

____

We would like to learn more about how people drive under different conditions. Do you think that most people vary their driving according to the way they feel?

(1)Yes_____ (2) No_____ Comment _________________________ 24,25_______
specify

____

When you are disturbed about something with other people, does it relax you to drive?

(1) Yes_____ (2) No_____ Comment_________________________ 26_______

____

Can you tell me how your driving is affected when you are angry?

____ 27,28 _______

____

Schenectady Sample
Card IV

Can you tell me how your driving is affected when you are sad or depressed? 29,30________

____

____

What do you do to wake yourself up when you get sleepy at the wheel? 31,32________

____

____

Do you consider yourself more nervous, less nervous, or about as nervous as other people? 33________

(1)More______ (2) Same______ (3) Less______ Comment______________________
specify

____

During the last three years have you had more or less than your usual share of worries? 34________

(1)More______ (2) Same______(3) Less_______Comment______________________

____

Do you smoke?

(1) Yes______ No______ Comment______________________________________ 35________

If Yes: How much do you smoke? ______________________________ 36,37________
(Be sure to note what they smoke)

Do you smoke while you are driving?

(1)Yes______(2)No______Other______________________________ 38________
specify

If No: Have you smoked in the last three years?

Yes______ No______ Comment______________________________

Do you drink? 39________

(1)Yes_____ (2) No______ Comment______________________________

If Yes: Are there occasions when you drive after having a drink? 40________

(1) Yes______ (2) No______ Comment______________________________

____

Schenectady Sample

The Health Department is interested in learning more about the general health of the people in the survey. Card IV

First of all, how tall are you?_________ 41________

How much do you weigh?_________

(Editing: Age of respondent from page 2 _________)

Are you troubled with:	Yes	No	If yes: Does this interfere with your normal routine? Yes	No	
Hay fever					42________
Asthma					43________
Diabetes					44________
High Blood Pressure					45 ________
Stomach Ulcer					46________
Arthritis, rheumatism, or neuritis					47________
Limited use of either your arms or legs					48________
Fainting spells or epilepsy					49________

Have you ever had any nervous or emotional illness? 50________

(1)Yes______ (2) No ______ Comment____ specify

____

Have you ever had any other chronic condition or long drawn-out illness? 51________

(1) Yes______(2)No______ Comment____ specify

____

Do you have trouble hearing? (1) Yes______ (2) No______ 52________

Comment____

Schenectady Sample
Card IV

Do you have trouble getting to sleep?

(1)Yes____(2)No____Comment____________________ 53_____
specify

Do you wear glasses? (1)Yes____(2)No____Other____________________ 54_____
specify

Do you usually wear sunglasses when you drive on sunny days?

(1)Yes____(2)No____Comment____________________ 55_____

What is your usual speed on the open road where there are no speed control zones?
____________________ 56_____

How courteous do you think other drivers are?____________________ 57-58_____

____

____

Comparing yourself with other drivers, how would you rate yourself in terms of driving skill?
____________________ 59_____
specify

____

Would you say you are a slow or a fast driver?

(1)Slow____(2)Fast____Comment____________________ 60_____
specify

____

____

Along the highways there are usually warning signs pointing out special conditions, dangers, or places where caution is called for.

Do you think that most people notice these signs as they are driving?

(1)Yes____(2)No____Comment____________________ 61_____
specify

____

____

Schenectady Sample

Do you believe stop signs are generally observed? Card I'

(1) Yes_____ (2) No_____ Comment ______________________ 62______
specify

____

____

Do you believe that it is necessary for drivers to come to a full stop at a corner stop sign they know when no one is in sight?

(1) Yes_____ (2) No_____ Comment______________________ 63______
specify

____

____

Would you say it was easy or difficult to find your way on strange roads?

(1)Easy_____ (2) Difficult_____ Comment______________________ 64______
specify

____

____

In your opinion are route signs too small, about right, or too large?

(1) Too small_____ (2) About right_____ (3) Too large_____ 65______

Comment____

What is the fastest you have ever driven on the open highway?__________ 66______

____

Have you ever been involved in a motor vehicle accident, large or small?

(1) Yes_____ (2) No_____ Comment______________________ 67______

If Yes: Were you driving?

(1) Yes_____ (No)_____ Comment______________________

How many have you had since you've been driving?__________ 68______

Did any happen to you since January, 1953?

(1)Yes_____ (2)No_____Comment______________________

If Yes: How many were there?______________ 69______

Schenectady Sample
Card IV

If had any accident since January, 1953: Now for the first one that happened to you:

Where did you have the accident?______________________ 70______
City and State

What was the approximate date?______________________ 71-72______
Month and Year

About what time did it occur?__________A.M.__________P.M. 73______

Was this with another car, object, or pedestrian?

(1)Another car______ (2)An object______

(3(Pedestrian______ (4)None of these______

Other______________________ 74______
specify

Was anyone injured? (1)Yes_____ (2)No_____ Other______________ 75______
specify

What was the total damage in terms of money to your car in the accident? 76-78______

$______________

If another car involved: What was the total damage to the other car in terms of money? $__________

If an object involved: What were the damages to the object? $__________ 79______

Was this accident reported to the Bureau of Motor Vehicles?

(1)Yes_____(2)No_____Other______________________ 80______
specify

Card V

Now for the second accident. 1______

2-5______

Where did you have the accident?______________________ 6 5

City and State 7______

What was the approximate date?______________________ 8-9______
Month and Year

What time did it occur?__________A.M.__________P.M. 10______

Was this with another car, object, or pedestrian?

(1)Another car (2)An object

(3)Pedestrian (4)None of these

(5)Other______________________ 11______
specify

Was anyone injured? (1)Yes_____(2)No_____Other______________ 12______
specify

Schenectady Sample
Card V

What was the total damage in terms of money to your car in the accident?

$__________ 13-15_____

If another car involved: What was the total damage to the other car in terms of money? $__________

If an object involved: What were the damages to the object?
$__________

Was this accident reported to the Bureau of Motor Vehicles?
(1)Yes____(2)No____Other__________ 16_____
specify

Now for the third accident.

Where did you have the accident?__________ 17_____
City and State

What was the approximate date?__________ 18-19_____
Month and Year

About what time did it occur?__________A.M.__________P.M. 20_____

Was this with another car, object, or pedestrian?

(1)Another car (2)An object__________

(3)Pedestrian (4)None of these__________

(5)Other__________
21_____

Was anyone injured? (1)Yes____(2)No____Other__________ 22_____
specify

What was the total damage in terms of money to your car in the accident?
$__________

If another car involved: What was the total damage to the other car in terms of money? $__________

If an object involved: What were the damages to the object? $__________ 23-25_____

Was this accident reported to the Bureau of Motor Vehicles?

(1)Yes____(2)No____Other__________ 26_____
specify

How many times since January, 1953 have you had to stop along the road because your car or other vehicle you were driving broke down or would not run right?

(1)Once____(2)Twice____(3)Three times____(4)Four times____

Add comments__________ 27_____

____

Do you think traffic laws are enforced strictly enough?

(1)Yes_____ (2) No_____ Comment_______________________________
specify

____ 28______

Why do you think so?_______________________________________

____

____ 29-30______

Let's see, I have one more question. In order to make some comparisons of the people who are interviewed, we need to know the approximate amount of the income of everyone in your household put altogether. Would you mind looking at this card and telling me the letter next to the figure that represents what your family income was for 1954?

(01) A____	(07) G____	(13) M____	
(02) B____	(08) H____	(14) N____	
(03) C____	(09) I____	(15) O____	
(04) D____	(10) J____	(16) P____	
(05) E____	(11) K____	(17) Q____	
(06) F____	(12) L____		31-32______

Thank you very much for giving us this information. Your answers will be kept confidential with no one seeing them other than a few of us doing the research. Are there any questions you would like to ask about the study?

One of the most important pieces of information needed in planning highways is how many miles people drive. Aside from very crude estimates based on amount of gasoline used, we have almost no good basis to go on. For this reason we wonder if we could ask your help in having some further accounts of the miles you drive in the months to come. We would like to have you, especially, do this because you are part of a sample of Schenectady citizens. I will be a very valuable contribution to our nation's road building program.

Schenectady Sample

Card V

NOTE TO INTERVIEWER: Complete this section immediately after you leave the house.

Schedule No. ____

A. Rate the house the family lived in by checking one of these descriptive phrases:

Large houses in good condition	____03
Large houses in medium condition: medium-sized houses in good condition.	____06
Large houses in bad condition	____09
Medium-sized houses in medium condition; apartments in regular apartment buildings.	✓ 12
Small houses in good condition; small houses in medium condition; dwellings over stores.	____15
Medium-sized houses in bad condition; small houses in bad condition.	____18
All houses in very bad condition; dwellings in structures not originally intended for homes.	____21

33-34________

B. Rate the area the family's house was in by checking one of these descriptive phrases:

Very exclusive; Gold Coast.	____02
The better suburbs and apartment house areas, houses with spacious yards.	____04
Above average; areas all residential, larger than average space around houses; apartment areas in good condition.	____06
Average; residential neighborhoods, no deterioration in the area.	____08
Below average; area not quite holding its own, beginning to deteriorate, business entering.	____10
Low, considerably deteriorated, run-down and semi-slum.	✓ 12
Very low; slum.	____14

35-36________

Give your overall impression of the family, house, and furnishings, by checking the place on the scale that corresponds to your judgment.

37________

Very low	Low	Average	High	Very high

Respondent rating:

38________

Tense	Restless	Relaxed	Very relaxed

Appendix C—Control Data

Control data are those which help form the background for evaluation of other findings in a study. Some of these can be indicated here before other results are given.

The 1,567 households visited in Schenectady formed the basic sample of the city. Of these, 810 were driver or interview households. The remaining 757 were called no-interview households because the only information secured was household composition. This group contained households in which no one had driven since January 1953, in which there was one driver but a random start of two, in which no complete contact could be made after one to six visits because of the termination of the field work, and in which the person refused to give any more than a fragment of the information needed (see Table 2).

Fewer than 19 percent of the people who would not completely answer the questions were important to the study, because of these only 1.1 percent were drivers who should have been contacted and 0.8 percent were in households in which the presence or absence of drivers was unknown.

Household composition was examined in several ways. As shown in Table 26, the number of people in most households was five or fewer, with about one-half having two or three members. Interviewed households tended to be larger, which is expected, since the random start of two for one-half of all households visited meant at least two members had to be of driving age, which put many one-person and one-driver households on the no-interview side. Table 27 shows that more than one-half of all households had no members under 16 years, with the higher proportion being in no-interview households.

Table 28 shows that more than one-half of all households had two members 16 years of age and over, who were therefore potential drivers.

In Table 29, two-thirds of all households were found to have one male adult member. Interview households were characterized by a higher proportion of male adult members and a lower proportion of no adult males than were no-interview households. Table 30 indicates somewhat greater similarity between the two types of households in total number of female adults.

Of all the sample households, about one-third contained one driver, less than one-third had two drivers, about 7 percent had three to five drivers, and about one-fourth had no drivers (Table 31).

Almost six out of ten sample households had a male driver and three out of ten had no male drivers. In contrast to these data (Table 32), Table 33 shows that more than three out of ten households had female drivers and less than six out of ten had no female drivers.

Other aspects of contacts made with households are instructive in terms of the interview methodology. With respect to the random start, the expected distribution was for one-half of the households to be one's and for the remaining to be two's. Table 34 shows that this was followed quite closely, with 51.6 percent of the households having a random start of one, which meant the oldest driver had to be interviewed, and 47.7 percent had a two, which meant an interview with the second oldest driver only.

In the training of interviewers, the importance was stressed of repeat visits to households until the necessary information was secured and in mastering good approach techniques. Table 35 shows that most people were interviewed in one or two visits, but that the number of visits required in some households was more than 10. This emphasis on securing everyone in the sample was partly responsible for the extremely low refusal rate in this work. This should be a basic consideration in any sample, as it had been demonstrated that distinct distortions in findings occur where the refusal rate is high or where volunteers are relied on to give data.

Time of day of final contact is of interest because, as expected, drivers had to be interviewed in the evenings. The distribution in Table 36 shows that more than six out of ten were interviewed after 4:00 P.M. Fewer no-interview households were completed during this time, as the composition information needed could be secured from anyone who answered rather than only the driver.

The dav of week of fınal contact (Table 37) was faırly even for everyone vısıted. The smaller number on Sundays reflects the customary expectatıon of a rest day on the part of ınterviewers as well as respondents. These weekly figures are resolved bv months in Table 38.

TABLE 26

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF PERSONS IN HOUSEHOLD

No. ın Household	No-Intervıew Households		Intervıew Households		Total	
	No.	%	No.	%	No.	%
1	152	20.0	30	3.7	182	11 6
2	232	30 6	219	27.0	451	28.8
3	120	15 9	202	25 0	322	20 5
4	80	10.6	183	22.6	263	16 8
5	43	5.7	115	14.2	158	10 1
6	20	2 6	43	5 3	63	4 0
7	5	0 7	10	1 2	15	1 0
8	3	0 4	3	0 4	6	0 4
9	1	0 1	2	0.2	3	0 2
10	47	6.2	2	0 2	49	3.1
11	---		1	0.1	1	0.1
Unknown	54	7.1	---		54	3 4
Total	757	100.1	810	99.9	1,567	100 0

TABLE 27

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF HOUSEHOLD MEMBERS 15 YEARS OF AGE AND UNDER

No 15 yr. or Under	No-Intervıew Households		Intervıew Households		Total	
	No	%	No.	%	No	%
1	88	11 6	157	19 4	245	15 6
2	73	9 6	137	16 9	210	13 4
3	36	4.8	73	9 0	109	7 0
4	13	1 7	26	3 2	39	2.5
5	3	0.4	1	0.1	4	0.3
6	---	---	2	0.3	2	0 1
7	---	---	1	0 1	1	0 1
0	483	63 8	411	50.8	894	57.0
Unknown	60	7.9	2	0.3	62	4.0
10 or more	1	0 1	---	---	---	---
Total	757	99.9	810	100.1	1,566	100.0

TABLE 28

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF HOUSEHOLD MEMBERS 16 YEARS OF AGE AND OVER

No. 16 yr or over	No-Intervıew Households		Intervıew Households		Total	
	No	%	No	%	No	%
1	176	23 2	37	4.6	213	13.6
2	363	48 0	506	62 5	869	55 5
3	80	10 6	168	20 7	248	15 8
4	24	3 2	70	8 6	94	6 0
5	6	0 8	19	2 3	25	1 6
6	2	0 3	6	0 7	8	0.5
7			1	0.1	1	0.1
0	45	5 9	---		45	2 9
10 or more	---	---	1	0 1	1	0.1
Unknown	61	8 1	2	0.2	63	4 0
Total	757	100 1	810	99 8	1,567	100 1

TABLE 29

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF MALE HOUSEHOLD MEMBERS 16 YEARS OF AGE AND OVER

No. of Males 16 yrs. or over	No-Intervıew Households		Intervıew Households		Total	
	No	%	No.	%	No	%
1	434	57.3	622	76.8	1,056	67.4
2	56	7 4	116	14 3	172	11 0
3	7	0.9	25	3 1	32	2 0
4	---	---	2	0.2	2	0 1
5	---	---	5	0 6	5	0 3
0	197	26 0	38	4.7	235	15.0
DK	63	8.3	2	0.2	65	4.1
Total	757	99.9	810	99.9	1,567	99 9

TABLE 30

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF FEMALE HOUSEHOLD MEMBERS 16 YEARS OF AGE AND OVER

No of Females 16 yrs or over	No-Intervıew Households		Intervıew Households		Total	
	No	%	No	%	No	%
1	480	63 4	588	72.6	1,068	68.2
2	91	12 0	157	19.4	248	15 8
3	16	2 1	32	4 0	48	3 1
4	2	0 3	4	0.5	6	0.4
0	106	14 0	27	3.3	133	8 5
10 or more	---	---	1	0 1	1	0.1
DK	62	8.2	1	0 1	63	4 0
Total	757	100 0	810	100 0	1,567	100 1

TABLE 31

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF DRIVERS IN HOUSEHOLD

No Drıvers	No-Intervıew Households		Intervıew Households		Total	
	No	%	No	%	No	%
1	293	38.7	249	30 7	542	34 6
2	23	3.0	463	57.2	486	31 0
3	---	---	73	9 0	73	4.7
4	5	0 7	18	2.2	23	1.5
5	1	0.1	7	0.9	8	0.5
None	383	50.0	---	---	383	24 4
DK	52	6.9	---	---	52	3.3
Total	757	99.4	810	100.0	1,567	100.0

TABLE 32

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF MALE DRIVERS IN HOUSEHOLDS

No Male Drivers	No-Interview Households		Interview Households		Totals	
	No	%	No	%	No	%
1	271	35 8	650	80 2	921	58 8
2	5	0 7	85	10 5	90	5 7
3	3	0 4	15	1 8	18	1 1
4	---	---	2	0 2	2	0 1
5	---	---	3	0 4	3	0 2
0	427	56.4	55	6 8	482	30 8
DK	51	6 7	---	---	51	3 3
Total	757	100 0	810	99 9	1, 567	100 0

TABLE 33

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TOTAL NUMBER OF FEMALE DRIVERS IN HOUSEHOLD

No Female Drivers	No-Interview Households		Interview Households		Totals	
	No	%	No	%	No	%
1	61	8 1	485	60 0	546	34 8
2	5	0 7	54	6 7	59	3 8
3	1	0 1	6	0 7	7	0 5
None	609	80 4	265	32 7	874	55 8
DK	81	10 7	---	---	81	5 2
Total	757	100 0	810	100 1	1, 567	100. 1

TABLE 34

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY RANDOM START IN HOUSEHOLD

No Random Starts	No-Interview Households		Interview Households		Totals	
	No	%	No	%	No	%
1	262	34 6	548	67 4	808	51 6
2	483	63 8	264	32 6	747	47 7
Unknown	12	1 6	---	---	12	0 7
Total	757	100 0	810	100 0	1, 567	100 0

TABLE 35

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY ACTUAL NUMBER OF VISITS MADE

No of Day Visits	No-Interview Households		Interview Households		Total	
	No	%	No	%	No	%
1	414	54 7	304	37 5	718	45 8
2	151	19 9	241	29 8	392	25 0
3	69	9 1	127	15 7	196	12 5
4	44	5 8	56	6 9	100	6 4
5	17	2 2	38	4 7	55	3 5
6	25	3 3	19	2 3	44	2 8
7	8	1 0	10	1 2	18	1 1
8	12	1 6	7	0 9	19	1 2
9	8	1 0	2	0. 3	10	0 6
10 or more	9	1 2	6	0 7	15	1 0
Total	757	99 8	810	100 0	1, 567	99 9

TABLE 36

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY TIME OF DAY OF FINAL CONTACT

Hour of Contact	No-Interview Households		Interview Households		Total	
	No	%	No	%	No	%
8-11 59 AM	27	3 6	22	2 7	49	3 1
12-3:59 PM	251	33 2	194	24 0	445	28 4
4-7 59 PM	320	42 3	416	51 4	736	47 0
8-11 59 PM	83	11 0	84	10 4	167	10 7
8-11 59 PM[1]	62	8 2	91	11 2	153	9 8
No Answer	14	1 8	3	0 4	17	1 1
Total	757	100 1	810	100 1	1, 567	100 1

[1] Or later

TABLE 37

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY DAY OF WEEK OF FINAL CONTACT

Day of Week	No-Interview Households		Interview Households		Total	
	No	%	No	%	No	%
Sunday	24	3. 2	24	2 9	48	3 0
Monday	122	16 1	132	16 3	254	16 2
Tuesday	124	16. 4	130	16 0	254	16 2
Wednesday	129	17 0	151	18 6	280	17 9
Thursday	98	12 9	108	13 3	206	13 1
Friday	142	18 7	151	18 6	293	18 7
Saturday	112	14 8	113	13 9	225	14 3
No answer	3	0. 4	1	0 1	4	0 2
Total	757	99 5	810	99 7	1, 567	99 6

TABLE 38

NO-INTERVIEW AND INTERVIEW HOUSEHOLDS COMPARED BY MONTH OF FINAL CONTACT

Month	No-Interview Households		Interview Households		Total	
	No	%	No	%	No	%
January	101	13 3	75	9 3	176	11 2
August	141	18 6	162	19 9	303	19 3
September	78	10 3	59	7. 3	136	8 7
October	98	12 9	123	15 0	221	14 1
November	124	16 3	182	22 5	306	19. 5
December	214	28 2	208	25 7	422	26 9
No answer	1	0 1	1	0 1	2	0 1
Total	757	99 7	810	99. 8	1, 567	99. 8

Situational Characteristics and Turn-Signalling Behavior

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Turn-signalling was chosen as an area of driver behavior worthy of intensive study. In this paper, the turn-signalling behavior of 10,467 drivers who turned at seven different intersections during daylight hours in the Greater Lansing area was related to various situational characteristics such as type of intersection, direction of turn, presence of following traffic, etc. The major findings were: (a) turn-signalling was significantly influenced by type of intersection; (b) female drivers generally signalled more frequently than male drivers and both generally signalled left turns more frequently than right turns; (c) turn-signalling behavior was not related to time of day, presence of preceding traffic and/or following traffic, or the signalling behavior of the preceding car.

● THE STUDY reported here was an exploratory one designed to provide some insight into the factors affecting the frequency of signalling for a turn by the driver of a motor vehicle.

The choice of turn-signalling behavior as an area of investigation was not a haphazard one. The assumption was made that driver behavior on the highway is an important area of study not only for the student of human behavior but also for those interested in efficient highway design and effective traffic regulatory and enforcement procedures. Turn-signalling behavior was selected for study because it seemed to provide certain advantages not readily found in most driver behavior situations.

First of all, turn-signalling could be observed in field situations with little if any distortion of the naturalistic situation. Also, a high degree of accuracy could be obtained in measuring this behavior and a number of related factors while using a minimum of equipment.

Second, it appeared likely that turn-signalling behavior would be related to a number of situational and individual characteristics. For example, turn-signalling, properly utilized, could serve as a communication channel between driver and driver and between driver and pedestrian about certain specific features of the traffic movement. Whether turn-signalling is, in fact, used to communicate intention to turn and under what circumstances it is so used was one of the questions that required investigation. Other motivations or habit patterns may equally well be hypothesized as factors relevant to turn-signalling. It might be related to attitudes resulting from law enforcement policies of a community, or to the felt "dangerousness" of a turning movement at a given intersection; or it might be related to individual personality characteristics or to driving habits that are relatively consistent from situation to situation for a given person.

Thus, it can be seen that turn-signalling was chosen for study not only for its own importance but also on the expectation that a systematic and analytic investigation of this behavior would yield suggestions pertinent to the understanding of driver behavior in many other traffic situations.

In this paper we shall describe the results obtained from exploring relationships between situational characteristics (such as type of intersection, direction of turn, presence of preceding and following cars, etc.) and the frequency of turn-signalling by drivers of passenger cars. No characteristics peculiar to the individual, with the exception of sex, are considered.

METHOD

General Procedure

A total of 120 hours of observations were made at seven different intersections in the Greater Lansing (Michigan) area. Four intersections were studied from mid-July to mid-August, 1956 (Sites 1-A and 1-B, 2-A and 2-B, 3 and 4). (See below for descriptions.) Preliminary analyses were made of the data obtained at these intersections. In order to replicate the findings and to test hypotheses derived from the summer data, three new intersections (Sites 5, 6-A and 6-B, and 7) were observed from mid-October to mid-November, 1956, and additional data were collected at a site previously studied (Site 1-A).

All data were collected during daylight hours and in good weather (no rain, fog or snow). On a few occasions the road was still wet from a previous rain. Initial observations were made during the early afternoon period. Additional observations were then made at other time periods in order to determine whether observations made at different times of day could be compared. The results obtained were consistent in indicating the lack of relationship between turn-signalling frequency and time of day. (Details of the comparisons are given in the Results section.) In general, observations were made during the early afternoon period (1:00 to 3:30 PM) unless checks were desired on signalling frequency at other times of day or unless the volume of turning traffic was so low during that time period as to make observations uneconomical.

The total number of hours of observation for each site is given in the site descriptions below. These were determined by the time required to obtain stable estimates of male signalling frequency, the number of check observations that were being made at that site, and by the feasibility of observing both right and left turning cars at the same time.

Subjects

The 8,319 male drivers and the 2,148 female drivers of passenger cars who turned at the intersections under study served as subjects.

Observation Sites

Observation sites were selected on the basis of several criteria. Since this was an exploratory study, a wide variation in type of intersection was felt desirable. On the other hand, an attempt was made to replicate some intersection features in order to obtain an estimate of their importance. Generally speaking, pedestrian traffic was quite low at all observation sites and an effort was made to avoid obtaining observations during peak pedestrian traffic periods. Both left and right turns were studied at each site unless otherwise noted. Data obtained on opposing legs of an intersection were combined since statistical tests indicated that opposing legs at the sites studied did not differ significantly in signalling frequency.

Site 1 was the intersection of two two-lane roads at a two-way stop near the center of the Michigan State University campus. The east-west road (Auditorium) was the secondary one; the north-south road (Farm Lane) was the primary one. Site 1-A observations were made on the east leg (15.5 hr); Site 1-B observations were made on the south leg (7.5 hr). Relatively few cars used the west leg. Posted speed limit was 25 mph.

Site 2 was the intersection of two two-lane roads at a two-way stop at the edge of the campus. The east-west road (Shaw Lane-Marigold) was the secondary one; the north-south road (Harrison) was the primary one. Site 2-A observations were made on the east leg (14.7 hr); Site 2-B observations were made on the north and the south legs (6.5 hr). The west leg carried considerably less traffic than the east leg. Posted speed limit was 25 mph, but it was often exceeded on Harrison which bears much traffic bypassing the campus.

Site 3 was the intersection of a four-lane undivided major highway (U.S. 16) and a two-lane road (Hagadorn) at a stoplight intersection about .4 mile to the east of the city limits of East Lansing. Site observations were made of left turns only from the highway (west leg) into the two-lane road (12 hr). Posted speed limit was 35 mph at the intersection and 45 mph just to the east of the intersection.

Site 4 is the intersection of a six-lane divided street (Grand River, also U.S. 16) and one of the major access roads to the campus (Haslett) at a multiple stoplight intersection. The access road on the campus side is three lanes wide (two outbound and one inbound) but decreases to two lanes within 50 yds of the intersection. Observations were made of right turns only from Grand River into the campus (7.5 hr). The intersection is within the city limits of East Lansing. Posted speed limit is 25 mph.

Site 5 was a stoplight intersection at the edge of campus with two-lane legs to the south (Harrison) and the west (Kalamazoo) and four-lane legs to the north and east of the intersection. Observations were made on the south leg (3.5 hr). Posted speed limit was 25 mph on the north-south road and 35 mph on the east-west road. This site is the next four-leg intersection north of Site 2 on Harrison.

Site 6 was the intersection (Cedar and Mt. Hope) of a four-lane divided expressway-type road (running north-south) with a specially widened street (running east-west). The expressway (also U.S. 127) in addition to its four lanes for thru or right turning traffic had a special lane for left turning cars made by cutting away the medial strip beginning about 50 yd from the intersection on both the north and south leg. A special left turn light controlled left turning cars and a portion of the signal light sequence was for left turns only from the expressway. Site 6-A observations were made on the north and the south legs (20 hr). Access was not controlled on the expressway and posted speed limit was 25 mph.

The intersecting street was normally a wide two-lane street. It was widened beginning about 50 yd from the intersection to provide a left turn, a thru, and a right turn lane for outbound traffic and one lane for inbound traffic on both the east and west leg. Pavement legends beginning about 40 yd from the intersection designated the left turn, thru and right turn lanes. Part of the expressway curb had been cut back for about 30 yd to facilitate right turns from the east-west street onto the expressway. Site 6-B observations were made on the east and west legs (22.5 hr). Posted speed limit was 25 mph.

The intersection is within the city limits of Lansing but well outside the central business area. Pedestrian traffic was controlled by pedestrian signals.

Site 7 was an intersection formed by the termination of the expressway described in Site 6 with the regular street system of Lansing. To the south of the intersection was the four-lane divided expressway (Cedar); to the north was an undivided four-lane street (Larch). The intersecting east-west street was four lanes wide and undivided (Kalamazoo). Site observations were made on the north and south legs (11 hr). The phasing of the stoplight was such that all other traffic was stopped when either the north or the south leg had the green light. Thus, there was no impediment to either left or right turns except that caused by pedestrian traffic. There were no special turning lanes or pedestrian signals. The intersection is close to the central business area of the city but not within it. Posted speed limit was 25 mph at the intersection and 35 mph just to the south of the intersection.

Observation Procedure

During any period of observation the following information was obtained for all cars turning from a given leg of an intersection or for all cars turning in a given direction from a given leg of the intersection: (a) signal to turn by observed car; (b) direction of turn; (c) sex of driver; (d) presence of a motor vehicle 100 ft or less behind the turning car when it began its turn; (e) presence of opposing traffic within 100 ft of the intersection; (f) phase of stoplight (red or green-yellow) when there was one. Information was also recorded on both turning and non-turning vehicles in a way that permitted the presence of a motor vehicle 100 ft or less ahead of the observed car to be determined.

The observer stationed himself near the intersection where the required observations could best be made. In most cases he was diagonally across the intersection from the observed traffic movement. At other times he stood 100 ft before the intersection along the leg being observed. During the early stages of this study two observers were used for each leg since data in addition to that described here were also being collected. Later, one observer was required per leg and two legs of an intersection were observed simultaneously.

TABLE 1

TURN-SIGNALLING FREQUENCIES AND PERCENTAGES AT THE VARIOUS STUDY SITES

Site		Right Turns				Left Turns			
		Sig.[a]	N. Sig.[b]	% Sig.	Total	Sig.	N. Sig.	% Sig.	Total
1-A	M[c]	35	106	25	141	439	480	48	919
	F[d]	19	46	29	65	111	59	65	170
1-B	M	285	275	51	560	91	56	62	147
	F	60	49	55	109	13	3	81	16
2-A	M	438	616	42	1054	174	136	56	310
	F	115	172	40	287	52	15	78	67
2-B	M	108	61	64	169	334	145	70	479
	F	9	7	56	16	44	17	72	61
3	M	—	—	—	—	382	62	86	444
	F	—	—	—	—	113	20	85	133
4	M	327	243	57	570	—	—	—	—
	F	135	60	69	195	—	—	—	—
5	M	53	54	50	107	141	63	69	204
	F	25	4	86	29	41	13	76	54
6-A	M	274	199	58	473	521	448	54	969
	F	58	45	56	103	215	120	64	335
6-B	M	138	272	34	410	497	191	72	688
	F	62	76	45	138	141	46	75	187
7	M	103	91	53	194	296	188	61	484
	F	36	18	67	54	85	46	65	131

[a] signalling
[b] not signalling
[c] males
[d] females

Michigan state law requires that intention to turn be signalled by either hand signal or electric signal but does not specify the distance this signal must be given prior to turning or make a distinction between a signal for a left turn and one for a right turn. Therefore, a driver was designated as signalling if he blinked his left or right turn signal light or gave any hand signal, except a hand signal for stopping, regardless of the direction of turn.

Reliability of Observations

The reliability of the observations was checked by determining the percent of agreement between two observers observing the same traffic. Percent of agreement of 99 percent or better was obtained for total number of cars turning, number of cars signalling, number of cars not signalling, sex of driver and direction of turn. All other observation categories gave percent of agreement of 93 percent or better. The cate-

TABLE 2

STATISTICAL COMPARISONS OF MALE TURN-SIGNALLING AT THE VARIOUS STUDY SITES

Sites	1-A	1-B	2-A	2-B	3	4	5	6-A	6-B	7
1-A	—	.01	.01	.01	—	.01	.01	.01	NS	.01
1-B	.01		.01	.01	—	.05	NS	.05	.01	NS
2-A	.01	NS		.01	—	.01	NS	.01	.01	.01
2-B	.01	NS	.01		—	NS	.05	NS	.01	.05
3	.01	.01	.01	.01		—	—	—	—	—
4	—	—	—	—	—		NS	NS	.01	NS
5	.01	NS	.01	NS	.01	—		NS	.01	NS
6-A	.01	NS	NS	.01	.01	—	.01		.01	NS
6-B	.01	.05	.01	NS	.01	—	NS	.01		.01
7	.01	NS	NS	.01	.01	—	.05	.01	.01	

NS – Not significant
.05 – significant at .05 level
.01 – significant at .01 level
See text for explanation of underlining.

gories concerned with stoplight phase and presence of opposing traffic had the lowest inter-observer agreement.

Frequency of turn-signalling determined under conditions designed to eliminate the possibility of the drivers noting the presence of the observers did not differ significantly from the frequencies obtained with observers in their usual observation positions.

RESULTS

The data gathered from the field observations were analyzed to determine the effects of type of intersection, sex of driver, direction of turn, presence of preceding and/or following traffic, turn-signalling of a preceding car, opposing traffic, and arrival at an intersection on the red or green-yellow phase on the turn-signalling of passenger cars.

Table 1 gives the number of cars signalling or non-signalling, the percent of turning cars signalling and the total number of turning cars for both male and female drivers turning left or right at the various observation sites. The small number of female drivers at some of the sites would suggest caution in comparisons involving female turn-signalling frequency at these sites.

Type of Intersection

Table 2 presents the results of Chi-square tests of comparisons of male turn-signalling frequency for the different sites. (Male frequencies are used because of greater confidence in the stability of the male results.) Significance figures given above the diagonal refer to comparisons for right turns; significance figures given below the diagonal refer to comparisons for left turns. Significance figures are underlined when the male turn-signalling frequency was higher at the site named in the column heading than at the site named in the row heading. Inspection of the table reveals that virtually every site differs significantly from every other site in turn-signalling frequency for both right turns and left turns.

The highest male signalling frequency was obtained for left turns at Site 3 (86 percent). This site was at a stoplight intersection in a semi-rural area. The turns were made from an undivided four-lane highway and the speed limit was in the highest category of all sites studied. The lowest male signalling frequency was obtained for right turns at Site 1-A (25 percent). This site is one of the legs of a secondary road at a two-way stop near the center of the campus with probably the lowest average speed of all the sites studied.

The lowest male signalling frequency for left turns was also found at Site 1-A.

The highest male right-turn signalling occurred at Site 2-B although the frequencies obtained at Site 4 and 6-A are not significantly different. Right turns at 2-B involved turning off a primary road at a two-way stop where speeds on the primary road were often somewhat in excess of the posted 25 mph. Right turns at Site 4 and 6-A, respectively, involved turning off a six-lane divided avenue and turning off a four-lane divided expressway-type road (both roads carrying U.S. highway traffic).

Site 6-B did not differ significantly in male right-turn signalling from Site 1-A, the site with the lowest percent signalling, although the difference was quite close to significance. Site 6-B involved turning off a specially widened two-lane street with a special marked right turn lane.

Site 6-A which is similar to the site possessing the highest left-turn signalling frequency (Site 3) with respect to average speed of traffic and traffic volume but which had a special left-turn lane and a signal phase for left turns only was significantly lower in male left-turn signalling than all other sites except 1-A, 1-B and 2-A and was not significantly different from Sites 1-B or 2-A. Site 7 was equivalent to Site 6-A in almost all respects but lacked the special left-turn lane. Male left-turn signalling is significantly higher at Site 7 than Site 6-A but all other statistical comparisons are the same as that of Site 6-A.

Other comparisons can be made by the reader using Tables 1 and 2 and the site descriptions in combination. The conclusion can be readily drawn that turn-signalling behavior appears to be quite sensitively related to intersection and road characteristics. The determination of relative importance of various intersection characteristics requires further study. The data tends to suggest that higher speeds at the intersection increased turn-signalling frequency and that special turning lanes and special turning phases of the stoplight sequence reduced turn-signalling frequency. It would also appear that a left turn lane is less important for reducing turn-signalling frequency than a special stoplight phase for left turns.

Time of Day and Related Factors

An objection that might be raised is that the obtained differences in turn-signalling between sites reflected characteristics related to time of day, time of year and different groups of drivers rather than intersection characteristics *per se*. Such an objection can not be unequivocally excluded but a number of check observations provide no support whatsoever for this interpretation of the results.

Initial observations at Site 1-A were made in the early afternoon hours. Check observations were made during the late morning hours on a subsequent set of days. No statistical differences were found in turn-signalling frequency. Three months after the initial observations an additional set of check observations were obtained. The initial observations were made in the summer by two observers who recorded different details on the same car; the fall observations were made by a different single observer. Volume had increased from about 100 vehicles per hour to about 160 per hour and, on one day of the fall observations, construction work which blocked

TABLE 3

STATISTICAL COMPARISONS OF MALE VS. FEMALE TURN-SIGNAL FREQUENCY

Site	Right Turns	Left Turns
1-A	NS	.01
1-B	NS	NS
2-A	NS	.01
2-B	ID	NS
3		NS
4	.01	
5	.01	NS
6-A	NS	.01
6-B	.01	NS
7	NS	NS

ID – Insufficient data for statistical test; See Table 2 for code.

a neighboring road diverted new traffic through the intersection. Not only were the signalling frequencies not significantly different but the percentages obtained were quite similar.

Other observations were made to determine the effect of volume and time of day with similar results. (It should be noted that a change in volume at a given intersection can usually not be obtained without also varying time of day although a change in time of day can often be made without change in volume.)

Observations were made at Site 1-B during early afternoon hours and during the late afternoon rush period. Volume increased from about 130 cars per hour to 230 cars per hour. Turn-signalling frequencies were not significantly different.

No significant differences were found in comparing noon hour traffic with morning rush traffic at Site 4 or in comparing early afternoon with late afternoon rush hours at Sites 6-A, 6-B and 7. This lack of difference is especially interesting in view of the fact that most of the early afternoon and late afternoon observations were made on different days for the last named sites.

It is also worth noting that in all cases where legs at right angles to each other at an intersection were studied, significant differences were found for male signalling frequency for both right and left turns between these legs but no significant differences were found between opposing legs.

The pattern of these checks is consistent in providing no evidence for the influence of time of day (and its associated volume) on turn-signalling frequency at the sites studied. The consistency of the results obtained at Site 1-A suggests that time of year (within the period studied) was not a significant factor. It is possible that these intersections differed markedly in the type of driver passing through these intersections. However, many of these sites were quite close together and would be expected to carry much the same population of drivers not only because of their geographical proximity but also because they were associated links in local transportation routes. Also, the data shows that different legs at an intersection do not differ in turn-signalling frequency when they are similarly constructed (all opposing legs studied were) but they do differ significantly when they are differently constructed.

Sex of Driver

Table 3 presents the results of statistical comparisons of male and female drivers for right turns and left turns at the various observation sites. The results may be summarized as showing that female drivers signalled significantly more than males or they did not differ significantly. They never signalled significantly less. The comparison was not made for right turns at Site 2-B because of insufficient data. (Chi square tests were not made in this study when any cell of the table had a theoretical frequency of less than five or when any two cells each had a theoretical frequency of less than ten.)

Direction of Turn

Table 4 presents the results of statistical comparisons of signalling frequencies for left vs. right turns for both males and females. The results for both males and females are consistent in showing that left turns were signalled significantly more than right turns or they were not significantly different. Right turns were never signalled at a significantly higher frequency than turns.

TABLE 4

STATISTICAL COMPARISONS OF RIGHT VS. LEFT TURN-SIGNALLING FREQUENCY

Site	Males	Females
1-A	.01[a]	.01
1-B	.01	NS
2-A	.01	.01
2-B	.01	ID
5	.01	NS
6-A	NS	NS
6-B	.01	.01
7	NS	NS

[a]See previous tables for code.

Presence of Preceding or Following Car

The effect of a car preceding the observed car by 100 ft or less of a car following the observed car by 100 ft or less and of the various combinations of these circumstances on the signalling frequency of the observed driver was also studied. Data from several sites were combined so as to provide an adequate number of cases for statistical analysis of female drivers and to provide different levels of turn-signalling.

Right turns at Sites 1-A and 2-A were combined. Right turns at 1-B, 2-B and 4 were also combined. Left turns at 1-A and 2-A were combined. Left turns at 1-B, 2-B and 3 were also combined. The grouping yielded two levels of turn-signalling for right turns (low and medium) and two levels for left turns (medium and high). There were no sites with a high signalling level on right turns or a low level on left turns.

Each of the four combinations of direction of turn and signalling level was analyzed for male and female drivers separately. No statistical differences were found in any of the following comparisons: (a) car ahead vs. no car ahead when there was no car behind; (b) car ahead vs. no car ahead when there was a car behind; (c) car behind vs. no car behind when there was no car ahead; and (d) car behind vs. no car behind when there was a car ahead. Similar results were found in analyzing the effect of a following car on male drivers only at sites 6-A, 6-B and 7.

In considering the negative nature of these findings, especially in relation to following traffic, it is important to keep in mind the manner in which the data were analyzed. There were only two categories with respect to a car ahead (within 100 ft or not within 100 ft). Likewise, there were only two categories with respect to a car behind (within 100 ft or not within 100 ft). Thus, both a car with another car behind it 101 ft and a car with no car behind it within sight would fall in the same category in the analysis, i.e., observed car has no car behind. It is possible that our drivers were responding to cars at further distances than 100 ft. The analysis is based on the assumption that in many cases there was no car in sight and that the closer the following car was the greater would be its effect. Further research is planned with more categories of following distances. The present data strongly suggests that turn-signalling behavior was not influenced by the presence of cars behind the turning car.

Signalling Behavior of Preceding Car

Pairs of cars were selected from the field records using the following criteria: (a) both cars turned at the site under study; (b) the following car was 100 ft or less behind the lead car when the lead car began its turn; and (c) no cars were in the same lane between the two turning cars. Sites were grouped in the same manner as in the comparisons for the effect of preceding and following car. The direction of turn and the sex of the driver of the following car determined the classification for the combination of driver sex and direction of turn. All comparisons failed to reach the .05 level of significance.

Opposing Traffic

The effect of opposing traffic within 100 ft of the intersection was also studied. No comparisons could be made for Sites 4, 6-A or 7 because the nature of these sites made the presence of opposing traffic irrevelant to the turning movement. The presence of opposing traffic significantly increased male left-turn signalling at Site 1-B (.01 level) and at Sites 2-A and 3 (.05 level), male right turn signalling at Site 2-A (.01 level) and female right-turn signalling at Site 2-A (.05 level). All other comparisons failed to reach the .05 level of significance or were not tested because of insufficient data (male right turns, Site 6-B; female right turns, Sites 1-A, 2-B, 5 and 6-B; female left turns, Sites 2-A and 6-B).

Stoplight Phase

Another situational characteristic that appeared likely to be related to turn-signalling was the phase of the stoplight when the vehicle reached the intersection. If it is red, the driver must stop before beginning the turning movement. If the signal is green or yellow, he can often attempt the turn without stopping and, in some circumstances, without changing speed. The data obtained at Sites 3, 4, 5 and 6-B and for right turns at 6-A were examined for the effect of stoplight phase. Males signalled significantly more for right turns (.05 level) at Site 4 when reaching the intersection on the green-yellow phase. Females signalled significantly more for left turns (.05 level) at Site 3 when reaching the intersection on the red phase. All other comparisons were not significant. The inconsistent nature of the findings and the fact that the signal phase category had the lowest reliability of any category suggest that these results are due to chance.

Type of Signal

Virtually all turn signals observed during the course of this study were made by means of electric turn signals. The highest percent of hand signals (6.5 percent) was obtained at Site 3, the site with the highest signalling percentage. Since there was such a widespread dependence on electric turn signals, it was thought advisable to obtain an estimate of the percent of cars in the area so equipped.

One hundred cars were sampled from each of six large parking areas on the campus by taking all cars in sequence from the entrance to the parking area. These areas were used by university staff and students and by visitors. Each car was inspected for a turn signal lever. The percent of cars equipped with electric turn signals did not differ significantly from parking area to parking area and averaged 85 percent. This percent was significantly different (.05 level) from the percent of cars using electric turn signals at Site 3.

It would appear then that under some circumstances virtually all cars with electric turn signals (93 percent) will use them. It would also appear that more than half of the drivers in cars without electric turn signals will not signal for a turn even in good weather during the summer and under circumstances that would cause almost all drivers in cars equipped with electric turn signals to signal.

On first impression it might seem that equipping a passenger car with electric turn signals increases the frequency of turn-signalling. However, another hypothesis is quite tenable: namely, most of the drivers of passenger cars which are not equipped with electric turn signals are not interested in signalling for turns. The two hypotheses are not mutually exclusive and will require additional study for their resolution.

DISCUSSION

The results of this exploratory investigation justify the use of turn-signalling behavior as an instance of driver behavior worthy of intensive study. The behavior could be measured in a reliable way and was found to be related to a number of situational characteristics (such as type of intersection and direction of turn) and to be unrelated to other situational characteristics (such as the presence of a following car and the signalling behavior of a preceding car) in ways that are not trivial or obvious. Additional research will be required to isolate significant intersection features and to determine the extent to which various situational factors interact. Research is also needed on the influence of individual characteristics in addition to those of sex.

Turn Signals for Motor Vehicles

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An analysis of accidents in Great Britain has shown that it is important that direction signals on motor vehicles should be readily seen from the front and side as well as from the rear, particularly by cyclists and motorcyclists. In the light of this information the relative merits of present-day examples of semaphore-arm and flashing turn signals for use on cars have been compared.

It is concluded, over the wide variety of conditions tested, that a side-mounted amber flashing indicator (the "amber ear") is the most effective indicator. A rear indicator was found to become less effective the nearer it was to the stop light. There seem to be advantages in mounting signals at drivers' eye-level, and amber colored signals appear better than red or white ones.

The side-mounted indicator is likely to be of help to cyclists and motorcyclists, who are the chief victims of serious and fatal turning-car accidents at road intersections in Great Britain.

The importance of standardization in the choice of direction signals is stressed and recommendations are made regarding the choice.

● BEFORE January 1954 drivers in the United Kingdom could glance at the side of another vehicle and expect to see the driver's intention to turn indicated by one of two signals, in roughly the same position, a driver's arm or an amber semaphore arm. The semaphore arms which were used emitted a steady light of unspecified intensity, usually about 1 candela, and this appeared as the arm swung out to its operating position.

After World War II, the introduction of flashing-type direction signals in other countries inevitably led to a reconsideration of the merits of the British system. Experiments were therefore carried out by Gibbs (1) of the Medical Research Council's Applied Psychology Unit at Cambridge, England to compare the two systems for speed of response, mistakes and "attention-getting" value. The semaphore arm was found to be superior to the low-intensity flashing units then available, except when viewed in bright glare from sunlight.

In spite of these results, from January 1954 flashing direction signals were permitted in the United Kingdom as an alternative to the semaphore-arm system, partly to help the motor-vehicle export trade. The regulations, still in force, specify the minimum area of the flashers and their position relative to the axis of the vehicle. Front flashers (white or amber) may be used in conjunction with rear flashers (red or amber) and may form part of the tail light. As an alternative, flashers at the sides of the vehicle may be used. The power of a bulb in a flasher, must be between 15 and 36 watts, but no maximum or minimum light intensity is specified for any type of direction signal.

Early in 1954 two British manufacturers started fitting flashing turn indicators. These early units were of very low intensity[1] and were combined with either stop or tail lights or parking lights. This meant that a driver in Britain had to look for five possible types of turn signals in a number of positions on the vehicle, a situation that gave rise to much adverse comment culminating in a representation to the authorities to ban flashing units.

However, the quality of the flashing units was soon improved very considerably and it was thought advisable, before further changes in the regulations were made, to determine whether one of the two systems was intrinsically superior to the other and to

[1]One unit offered for sale fulfilled the legal requirements but had a light output of only 3 candelas compared with 200-300 candelas for efficient units.

see whether any of the inherent difficulties of the flashing-light system could be reduced.

TURN SIGNALS AND ACCIDENTS

The types of collisions involving serious or fatal injuries occurring at junctions have been studied in an attempt to find the numbers of accidents which would be expected to be affected by the use of clearly visible signals. The accidents selected for study were those in which a car was turning at a junction. The most frequent accident of this type is when a car is turning right[2] and is in collision with an oncoming vehicle, the next most frequent is when a car turns right from a side road, and the third most frequent is when a car turns right and is struck by an overtaking vehicle, which in two-thirds of the cases of this type of accident were motorcycles. This proportion is high partly because only serious and fatal accidents were considered and motorcyclists are more liable to get seriously hurt. These facts about accidents indicate that turn-signals should be clearly visible from the front and side as well as from the rear and should be easily seen by motorcyclists.

It was hoped, that from the beginning of 1954, as new cars came on the road fitted with flashing indicators any differences would be detectable from their changed liability to accident. However, for reasons connected with the methods used for recording accident data, this has not yet been found possible.

A series of observations were carried out to find the frequency with which direction signals are seen and the direction in which they appear to the driver of a vehicle. The following information was obtained from some 3,000 observations:

1. While driving in London the average distance away at which a direction signal was noticed was about 50 ft.
2. Half the signals were turn-right signals of approaching vehicles; there were comparatively few turn-left signals seen of vehicles proceeding in the same direction.
3. Most of the signals were seen through a small area of windscreen about 20 deg wide but with quite a small vertical range. Semaphore arms and flashers mounted on the side of the vehicle were seen horizontally or just below but flashing indicators were about 4 deg below the horizontal.

It was noticed during this survey that flashing lights on the roofs of vehicles (such as taxis) tended to be confused with traffic lights, flashing beacons and advertisement signs, whereas bottom flashers were confused with brake-lights, rearlights, reflectors and strong reflections from chromium. The semaphore arm appeared to lie in a comparatively "signal free" zone.

RELATIVE EFFECTIVENESS OF VARIOUS SIGNALS

In view of the inconclusive accident data and some considerable modifications in the type of flashing signal available, it was decided, in 1955, to re-examine experimentally the relative effectiveness of the various signal systems. There are now a wide variety of turn signals on the market, some with a light output 10 or 20 times greater than those originally tested at Cambridge and referred to above. Arrangements were made, therefore, in June 1955, to compare some of the brightest of these new flashers with the conventional semaphore arm.

The Cambridge results had, however, shown conclusively that the mounting of a stop light, flasher and rear light in the same fitting was unsatisfactory, causing confusion and giving rise to numerous errors. This conclusion is so clear-cut and a matter of everyday experience that it was considered unnecessary to repeat in any great detail experiments to demonstrate this. The following questions were therefore set down for answer:

1. (a) If rear or side flashers are arranged so as not to be confused with the stop light, are they more effective than a semaphore arm?
   (b) Is any form of front flasher more effective than a semaphore arm?

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[2]It should be remembered that vehicles keep to the left in Great Britain.

2. What is the best position to mount turn signals?

3. If two signals have the same color and intensity, which is the more effective — one that shows a flashing light or one that is steady?

The first series of experiments (Experiments 1-8) to be described answer questions 1(a) and 1(b). Test series 2 (Experiments 9-11) answers question 2 and the final question is answered by the third series of experiments (Experiments 12-17).

Experimental Method

An effective turn signal is defined as one which will command a driver's attention and at the same time be easily and therefore quickly interpreted. In the experiments to be described a number of subjects were placed in an experimental situation and the speed of their response to various turn signals was measured. In some experiments the vehicle carrying the signal was stationary, in others it was moving, but in both cases efforts were made to preserve what was judged to be the relevant essential features of a driving situation.

For the static tests, each person (called here the subject) was seated in a car and tested individually. The subject observed another car fitted with various signals and situated some distance away; in the preliminary instructions the subject's attention was directed to a continuous task. This consisted in maintaining in a horizontal position a white rectangle, the target, which was seen against a black background and placed some distance to one side of the car on which the signals were mounted (see Figs. 1 and 2). The position of the target was disturbed in an irregular manner and the

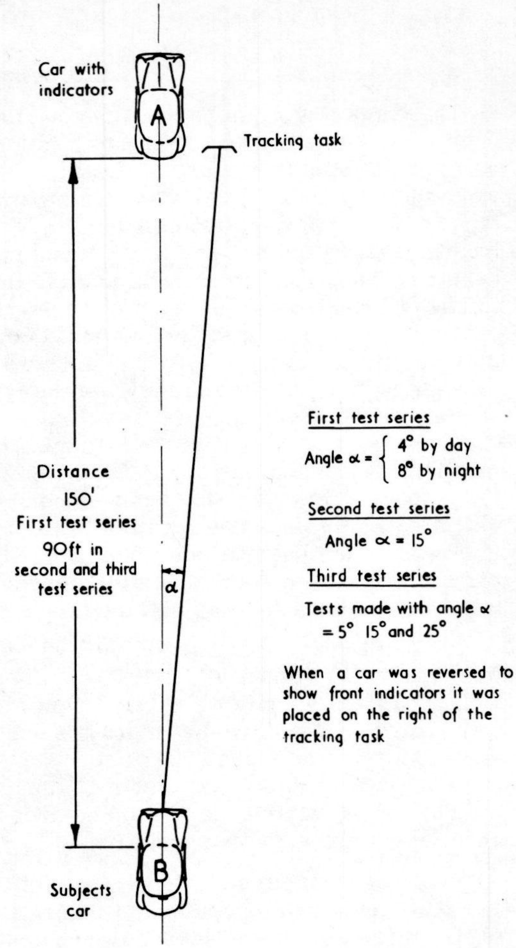

Figure 1. Plan showing the layout in the static experiments.

Figure 2. Test vehicle from front showing the levelling task to the left of the vehicle.

TABLE 1

TYPES OF SIGNAL SYSTEM AND THEIR APPROXIMATE LIGHT INTENSITIES

Turn Signal	Axial light intensity (candelas)
Standard semaphore arm	1
Red-colored flashers at rear	18
Amber- " " mounted on door pillar above semaphore arm (here called the "amber ear")	170
Amber- " " at rear (here called the "amber indicator")	240
Amber- " " mounted under headlamp	240
White- " " " " "	390

subject was enabled, by means of a remote control device, to correct this by turning the steering wheel. His attention was therefore concentrated on the levelling task, which was quite difficult, but at the same time he was required to respond to a signal on the test vehicle which was in a direction different from the one in which he was looking. Response to a signal consisted in pressing a conveniently situated lever in one of two direction, corresponding to whether "left" or "right" was indicated. The correct response switched off the signal. Subjects were instructed to extinguish each signal as it appeared as quickly as possible and were further told that their time to respond would be measured. The average response times to each signal has been used as a measure of signal effectiveness; the smaller the response time, the more effective the signal. If the response time was large, it was deduced that there were perceptual difficultires or else that the observer was forced to make a complex decision; if it was small, the signal was regarded as easily seen and easily interpreted. The differences in the scores obtained, although small, were usually real and not chance differences. Although under test conditions these differences are small, under road conditions the response times will probably increase until, when a driver is hard pressed, he may see those signals found best under test conditions but may fail to see the others. Some justification for this will be found in the results which will be given, for where there are gross differences in the ease of seeing, such as between indicators situated near to and those far from glaring headlights, the response times are significantly different in the way expected from common experience (see Fig. 4), although the absolute differences are relatively small.[3]

TABLE 2

TURN SIGNALS SEEN FROM THE FRONT OF A CAR, RANKED IN ORDER OF EFFECTIVENESS

Type of Signal	Conditions of Test		
	Day	Night	
		Undipped	Dipped
Semaphore arm	1[a]	2[a]	4
Amber ear (flashing)	1[a]	1	1
Amber indicator (flashing)	4	2[a]	2
White indicator (flashing)	3	4	3
Number of subjects	10	6	6

[a]Results such as two firsts mean either that the effectiveness scores were the same or so close that chance variations would account for the difference. Each test is based on 120 responses by each subject.

[3]In general, it has been found that the response time to a stimulus varies approximately with the inverse of the logarithm of the physical measure of the intensity of the stimulus and also depends upon the complexity of the total task over a wide range of stimuli and conditions. A survey of some of the relevant experiments will be found in (2).

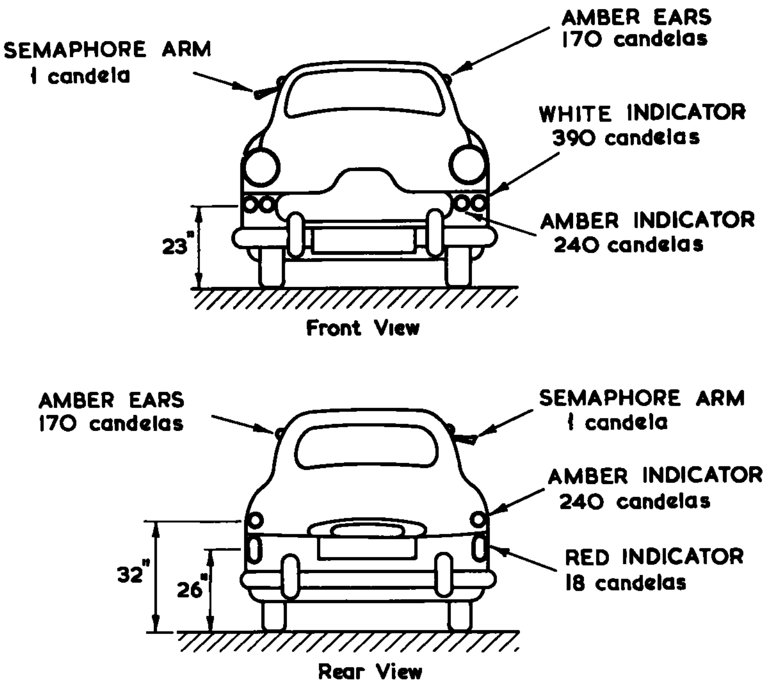

Figure 3. Diagram showing position and maximum intensities of direction signals. The signals were all additional fittings: the vehicle's own signals were not used.

Static Tests (Experiments 1 to 7)

Using the method described above, a comparison was made of the five types of signal, details of which are given in Table 1.

The positions of these signals on the experimental vehicle are shown in Figure 3. All types are in common use in the United Kingdom, the "amber ear" being frequently seen mounted on the roogs of London taxis. A plan of the experimental arrangement is shown in Figure 1. No vehicle stop light was in use in this series of tests.

These experiments were carried out in a variety of conditions, on sunny days and dull days, with the front of the observed car visible, with the rear visible, by night as well as by day. The results are given in Tables 2 and 3 in the form of a ranking of effectiveness of each type of signal under each condition tested. The numerical values on which these are based are illustrated in Figure 4.

Two further experiments (6 and 7) were carried out in the daytime with twenty subjects. In these, the subjects simply waited for and responded to the signals as fast as possible, i.e., the distracting task was not used. The variations in the speed of interpreting the direction indicated was thus found, and it was shown that the rank

TABLE 3

TURN SIGNALS SEEN FROM THE REAR OF A CAR, RANKED IN ORDER OF EFFECTIVENESS (NO STOP LIGHT IN USE)

Type of Signal	Conditions of Test	
	Day	Night
Semaphore arm	1[a]	4
Amber ear (flashing)	1[a]	1[a]
Amber indicator (flashing)	3	1[a]
Red indicator (flashing)	4	3
Number of subjects	10	6

[a]Results such as two firsts mean either that the effectiveness scores were the same or so close that chance variations would account for the difference. Each test is based on 120 responses by each subject.

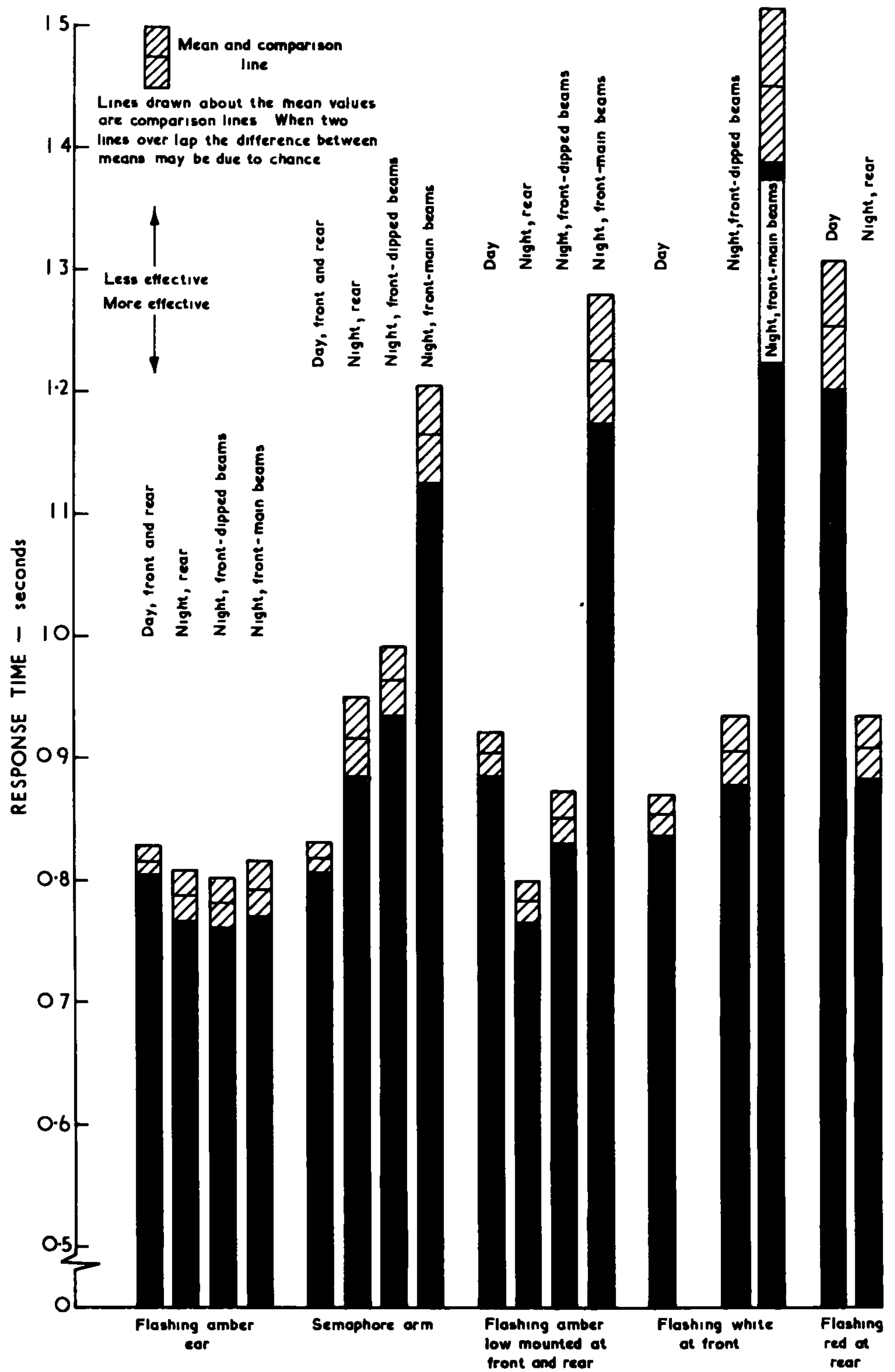

Figure 4. Response times to indicators: attention drawing under four conditions of background illumination (stop lights and side lights not used).

order of types of indicators was substantially the same as that found when the attention was directed away from the indicators. Thus, an indicator which is most easily interpreted seems likely also to be the best to attract attention.

Road Tests (Experiment 8)

These tests were carried out in the daytime to check whether the results from static tests could be generalized and applied to moving-vehicle tests. Moving-vehicle tests are more difficult to carry out and, owing to the large number of irrelevant factors which affect the performance of the task, the results tend to be very much less clear cut than those of the static tests.

Each subject was asked to drive a car about 20 to 25 yards behind a car fitted with the types of signal described. When the leading vehicle signalled a turn, the observer was instructed to do likewise and then follow the leading vehicle into the turn. Sixteen observers were used; the course followed took the vehicle through town, residential and country roads, and during the journey 29 left and 32 right (signalled) turns were made. In these experiments the stop light, which was in the same housing as the red indicator, was in normal use.

The initiation of a signal by the leading driver was recorded in his vehicle on a moving paper record. The instant the subject made his response it was relayed by radio link to the recorder in the leading vehicle, and response times could thus be measured directly from the chart. The results obtained in this experiment were insufficient to say with confidence which of the three indicators, low-mounted amber, amber ears, or semaphore-arms was most effective; it was clear, however, that the red flashers were least effective. In general, therefore, the moving tests tend to confirm the general pattern of results obtained in the static tests.

POSITION OF SIGNALS

Direction signals are at present arranged in vehicles in positions convenient to the manufacturer or pleasing to the stylist. This practice does not necessarily give the optimum position for ease of seeing and it has led to the present situation in Britain where a driver has to scan a vehicle from roof level to bumper level in order to be certain to see an indicator. Several experiments have therefore been carried out to decide which of a number of possible positions of front and rear signals is best. All the units used in these experiments were of one type, the 240-candelas amber indicator, arranged so as to give a steady signal or a flashing signal as required.

The most effective position of a signal in the test situation may, to some extent, depend on the height at which the distracting task is set. Some simple experiments showed that when driving on a level road a driver is chiefly interested in objects lying in a zone roughly $1\frac{1}{2}$ deg above horizontal, to $3\frac{1}{2}$ deg below, the most important zone lying between $\pm 1\frac{1}{2}$ deg from the horizontal. The distracting task was accordingly set about 1 deg below horizontal so that the subjects' eyes were directed in roughly the same direction as in a road situation.

As Seen from the Rear (Experiment 9)

Amber indicators were mounted at three different heights, 3, 9 and 18 in., center to center, above the stop light. Static tests were carried out by day and by night using each signal and switching on the stop light from time to time to simulate conditions as seen from the rear. The subject responded to the indicators as before and to the stop light by pressing the foot brake. The arrangement of the indicator, and the results, are shown in Figure 5. It will be seen that as the indicator is moved nearer to the stop light there is a decrease in effectiveness; when the separation was less than 9 in. the decrease in efficiency was very marked.

As Seen from the Front (Experiments 10 and 11)

At night the front turn-signal may have to be perceived against the glare from a headlamp. In practice conditions are even more difficult because the front indicator is often combined with a side light; this arrangement is clearly unsatisfactory and was not

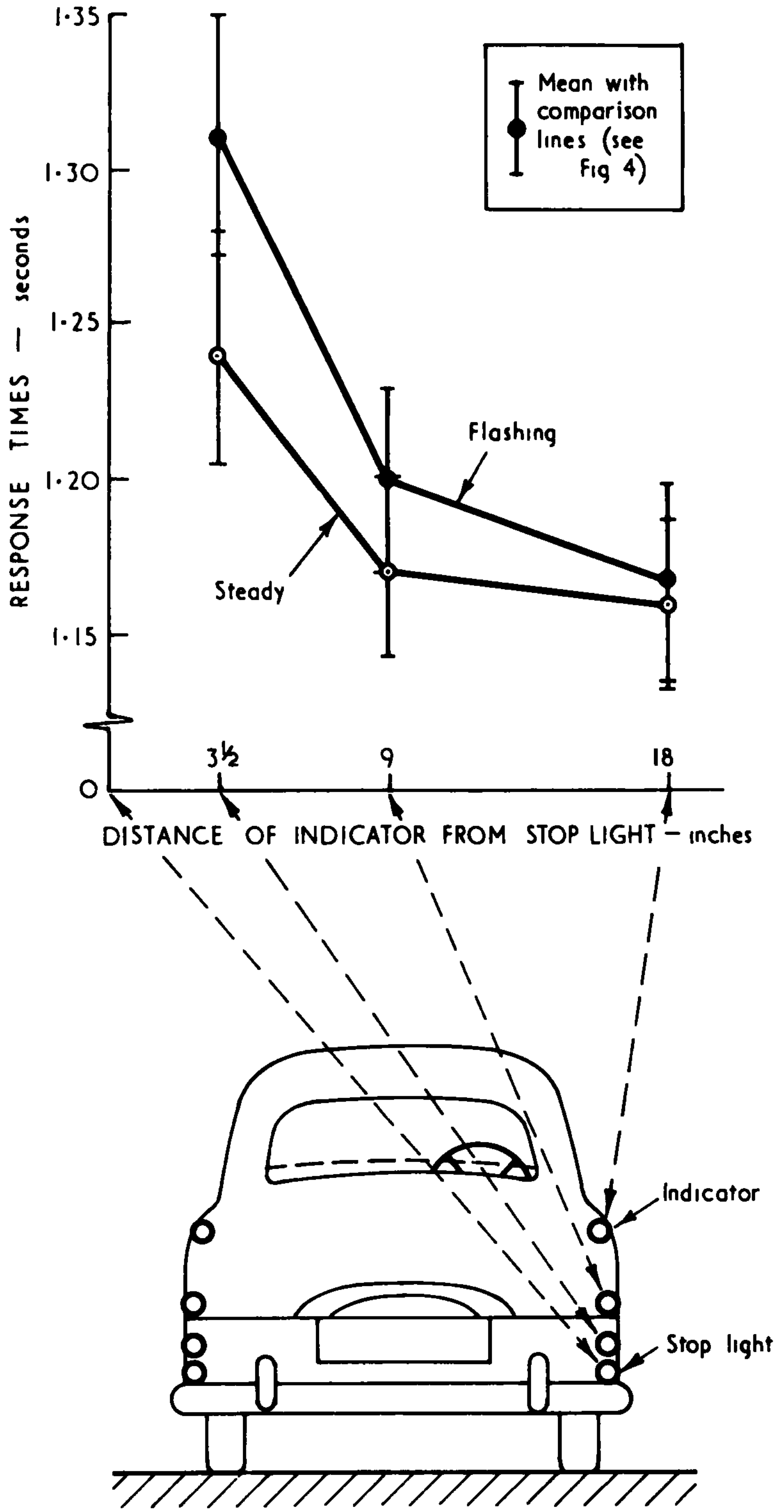

Figure 5. Response times to identical turn-signals mounted various distances from stop lights. Average of day and night results (18 subjects).

studied. The effect of arranging indicators to left and right of the headlamp and also below and above was investigated. In experiment 10, four amber indicators were arranged at equal distances of 9 in. from each headlamp, one above and one below it. The arrangement and results are shown in Figure 6. No differences were found in this experiment for signals above and below, but signal units outside the headlamps were better than those between them.

In experiment 11, four signals were arranged above and below the headlamp. The arrangement and results are shown in Figure 7. The signal mounted at semaphore-arm level was found to be more effective than signals above or below this position.

As Seen by Cyclists and Motorcyclists

The accident figures (Appendix A) show that, in roughly 50 percent of serious and

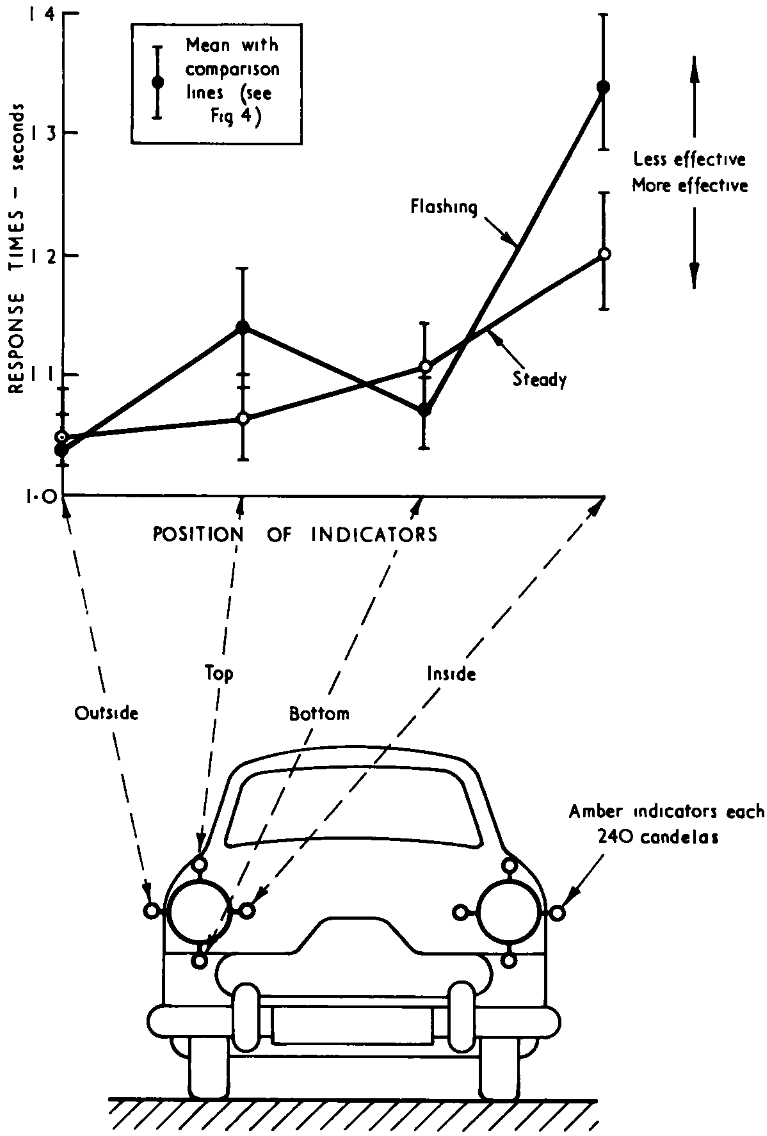

Figure 6. Response times and position of front turn signal. Four positions each 9 in. from center of lamp: night tests with headlamps dipped (9 subjects).

fatal accidents to a car turning at an intersection, the colliding vehicle was a motorcycle or a pedal cycle, either overtaking or colliding head on. It may be asked, "Which indicator is likely to be most readily seen by a motorcyclist, an amber ear or a low-mounted amber indicator?" Some simple geometrical considerations may assist in finding an answer.

If the average position of a motorcyclist's eyes when riding is assumed to be directed in a zone +1½ deg to -3½ deg relative to the horizontal in a similar way to the eyes of a car driver, Figure 8 shows the angle below the horizontal to which a motorcyclist must lower his eyes to see the amber ear and the low-mounted amber. The motorcyclist is supposed to be of average height and to be overtaking (or meeting) a car and passing it five feet from the side. It will be seen that the amber ear is always in the

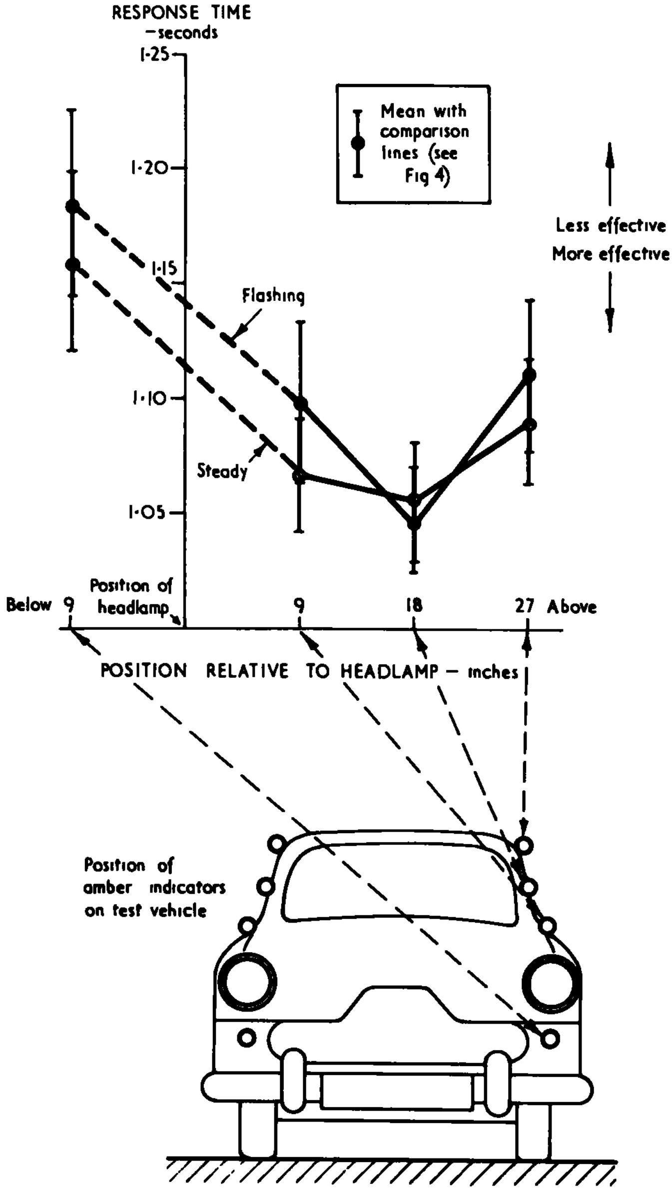

Figure 7. Effect (at night) of placing a turn signal at various heights above and below a headlamp (10 subjects).

horizontal plane, that is, it remains at eye-level but in order to see the low-mounted amber indicator the rider has to depress his eyes from the horizontal, and at distances less than 30 ft from the vehicle it is outside the normal field of view.

In busy urban traffic, distances between following vehicles are less than this. It is true that this advantage of the amber ear may be partly compensated by the higher intensity of the low-mounted amber indicator, but, near to the car on this count too, the amber ear is superior (Fig. 8).

Similar geometrical considerations apply to following motor vehicles; the difference is accentuated in the case of cyclists who have a high eye level. Cyclists and motorcyclists are frequently killed or injured when they are riding parallel with a car which turns left (see item 5 in the table in Appendix A). Figure 8 shows that the amber ear emits about 15 candelas at right angles to the side of the vehicle and would thus be of assistance to riders level with the vehicle. In this position front and rear indicators cannot be seen.

It is concluded that from the point of view of cyclist and motorcyclist the position occupied by the amber-ear indicator on the side of the vehicle is best because it is

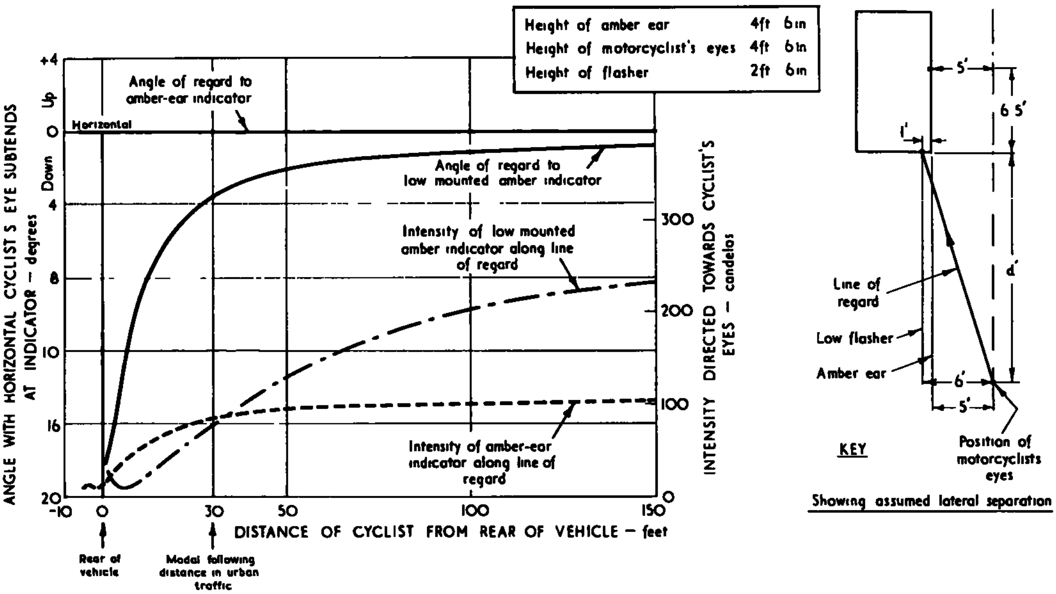

Figure 8. Visibility to the motor cyclist of low and high mounted signals. Variations in intensity and angle of regard for various distances from the vehicle.

nearer to the rider's line of vision and is easier to see when the cyclist is close to the vehicle.

FLASHING VERSUS STEADY SIGNALS

(Experiments 12 to 17)

Although the best flashing signals are more effective than the semaphore arm at night they are so much brighter that it cannot be said that the effectiveness is necessarily due to the flashing. Would the amber ear be equally effective if it emitted a steady light of the same brightness? Both static and moving vehicle experiments have been carried out to test this point.

Three conditions of background were considered: (a) conditions such as might occur on the open road when indicator lights on one vehicle are the only lights visible to a driver; (b) conditions such as might occur in an urban area where there are a number of steady lights in the field of view; (c) conditions such as will occur in urban areas when many vehicles have flashing lights and the relevant one has to be picked out. The distracting lights were arranged on either side of the test vehicle, which was itself placed at 5 deg to the line of sight to the levelling task. This angle was increased to 15 and 25 deg at other times.

The test vehicle had four turn signals; two of them amber ears and two amber indicators, and all four could be arranged to give either a steady signal or to flash 120 times a minute.[4]

Static Tests

By day the test vehicle was viewed from the rear but no stop lights were used; by night the vehicle was viewed from the front. Summarized results are given in Table 4 and in more detail in Appendix B.

At night when seen from the front in the glare of dipped headlamps the flashing indicators were, on the whole, best. By day, there was no consistent difference between steady and flashing indicators.

Road Tests

In addition to these static tests a further series of road experiments were carried

TABLE 4

STEADY VERSUS FLASHING DIRECTION SIGNALS OF THE SAME INTENSITY: STATIC TESTS: VEHICLE VIEWED FROM FRONT

Condition of test:		Most effective signal from:	
Day or night	Background	Amber-ear indicators	Low-mounted amber indicators
DAY (Rear of car in view)	Neutral (no lights)	No difference[a]	No difference
	Flashing lights	" "	" "
	Steady lights	Flashing	" "
NIGHT (Front of car in view)	Flashing lights	Flashing	No difference
	Steady lights	"	Flashing

[a]"No difference" means that differences were so small that they could be due to chance variations.

out in daylight to compare steady and flashing low-mounted amber indicators with amber ears; detailed results are given in Appendix B. In these tests, there appeared to be an advantage in using the steady lights, but this may have been due to chance variations.

A similar slight advantage was found in the daytime static tests but this also was within the limits of chance variation. A small non-significant difference in favor of steady signals was also observed in most of the experiments to determine the best position of the indicator (Figs. 5, 6, and 7). In each case the flashing condition improved more rapidly than the steady one, until at the best indicator position the two conditions were almost indistinguishable, the flashing condition being perhaps slightly better.

Summarizing, there is very little difference between the effectiveness of steady direction signals and signals flashing at 120 per min. For practical purposes they may be regarded as equally effective; such differences as there are appear to depend on the background against which the indicators are viewed and upon the personal characteristics of the subjects tested.

[4]A flash rate of 120 per min has been shown by others (3) to be more effective than rates of 60 flashes per min. The legal limits of rate of flash for motor vehicles are between 60 and 120 per min but most indicators on vehicles have frequencies at the lower end of the range.

DISCUSSION OF RESULTS

Indicator effectiveness has been shown to depend on color, position, and light intensity. The amber ear and the low-mounted amber indicator are better than the white indicator under adverse conditions. It is, therefore, an advantage for an indicator to show an amber light.

The experiments on the position of turn signals showed that the signal should be sited as near as possible to the normal line of sight and away from headlights and stop lights which are sources of interference.

In the static experiments the levelling task was arranged slightly below the driver's eye level. This was done in order to keep the subject's attention in roughly the same level as would occur during driving. It may be argued that this is the reason why eye-level indicators were found to be better but this cannot be the complete explanation as the results of the tests when no levelling task was used (Experiments 6 and 7) also gave the same result.

There are several other factors in a road situation which may favor signals at semaphore-arm level and these factors were also present in the experimental arrangements. For example, it may be that long usage has led drivers to expect signals at semaphore-arm level. In bright sunny weather subjects often reported difficulty in seeing low-mounted signals because of interference from the high intensity reflections of the sun on the chromium of the bumpers: this is illustrated in Figure 9 which is a photograph of a vehicle with a moderate amount of chromium taken in bright sunlight. The picture has been overprinted photographically to show the very bright reflections on the bumper; calculation showed that the brightest of these was about 5,000 candelas. When the car is in motion, the position of these highlights will form a changing pattern against which a driver is expected to see a flashing light of a few hundred candelas. Signals mounted on the side of the car are visible against the distant road scene which is usually darker and therefore a more effective background.

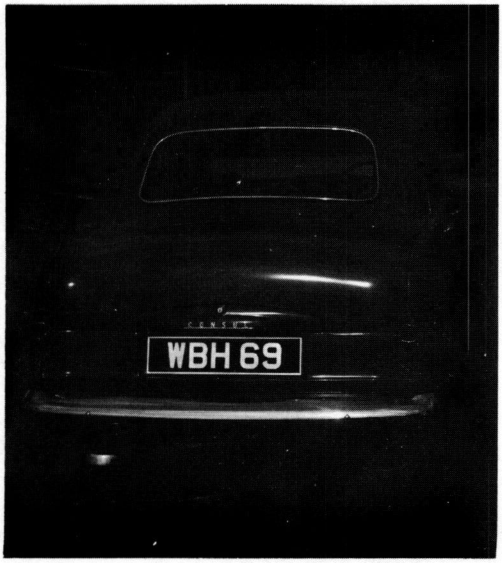

Figure 9. Rear view of a car with a moderate amount of chromium, taken in sunlight but printed so as to show several high lights. The distorted image of the sun at the right of the bumper has an intensity of the order of 5,000 candelas several hundred times greater than the adjacent flasher. The good background conditions higher on the vehicle will be noted.

One problem which has not been investigated is the reported annoyance produced by "winking lights". There is much clinical evidence that flashing lights of high intensity can precipitate epileptiform seizures[5] in some people (4) (5) (6). Frequencies as low as 3 per second can produce such effects in very young children (7) but higher rates 8 to 10 per second are generally required to produce seizures in adults. Flashing signals may have a maximum frequency of 2 a second, but a number of vehicles in a row could conceivably produce a combined frequency two or three times this. The intensity for direction signals is probably far too low to have any serious effect, although it is a question which in Great Britain might well be referred to the Medical Research Council for comment. The fact that some people are disturbed and irritated by flashing lights

[5]Such seizures, the symptoms of a variety of disturbances, may vary in form from a momentary twitch or inattention to a "grand mal" convulsion.

in a way which might lower their driving efficiency may well be a very mild manifestation of the phenomenon.

There are several factors concerning the relative merits of steady and flashing lights which either have not been investigated or which cannot be effectively assessed experimentally. Amongst these factors are the importance of the distraction from the task of driving caused by many flashing lights seen at the same time, the attention-drawing quality of a signal seen for the first time in operation (i.e. when the actual switching on is not observed due to the presence of another vehicle), and the importance of the time-lag in the operation of the flasher unit. This lag is due to a defect in the design of the units which, in effect, start their cycle of "on-off" periods with an "off". Although flashers can be made with very small delays, common types in use have an operating delay of up to one second before the first flash appears. Semaphore-arm signals, on the other hand, take only about one-quarter of a second to reach this final position.

The experiments which have been described were concerned with human response to a signal once it had appeared; mechanical delays in flasher units were therefore neglected because, for the purposes of the experiment, they were irrelevant. However, in an actual road situation some account must be taken of this lag of possibly a second's duration. In most cases a driver operates his indicator some time before he intends to turn and the fact that the signal does not show immediately may be of little importance. Nevertheless, circumstances do sometimes occur when, for example, a decision to turn or to overtake is taken suddenly and a delay of one second in the signalling system may be of vital importance.

CONCLUSIONS

The experiments described in this paper show that the color of a direction signal is important and that under adverse conditions amber indicators were better than white or red. Experiments using flashers of a range of intensities up to 400 candelas indicate that an intensity of at least 100 candelas is required in daylight; at night a lower intensity is probably effective. Other work suggests that intensities of more than 500 candelas are likely to prove glaring at night.

At night, when the experimental vehicle, with headlights on, was viewed from the front, the amber ear was the most effective indicator. From the rear (when the stop light was not in use) the low-mounted amber and the amber ear were equally effective.

By day, the amber ear and the semaphore arm were better than all other indicators. It is concluded, therefore, that over the wide variety of conditions tested the amber-ear indicator is the most effective.

A rear indicator was found to beome less effective as it was moved nearer to a stop light; when the separation, center to center was less than 9 in. the decrease in efficiency was marked; there seem to be advantages in mounting signals at driver eye level.

It is shown that the side-mounted indicator is likely to be of help to cyclists and motorcyclists who are the chief victims of serious and fatal turning-car accidents at road intersections.

Some experiments have also been carried out to test the comparative merits of direction signals when illuminated by a steady light or by a flashing light of equal intensity, in each case the housing being the same as that used for the flashing light. Under some conditions flashing lights were slightly more effective; under others, steady lights were better, but differences were small. However, no change from the existing practice of using indicators that flash can be recommended because of the limited scope of the experiments.

In all problems of this kind standardization is of fundamental importance so that an observer knows as far as possible where to look and what to expect as a signal. It is important, therefore, that one type of indicator should be selected for general adoption and that alternatives should be avoided. Associated with standardization is the importance of not using the same color for stoplights and direction indicators. All direction indicators therefore should be amber and this color should not be used for other vehicle lights.

The conclusions of the investigation are therefore that:

(1) Direction indicators should be amber in color and this color should not be used for other vehicle lights.

(2) At night the indicator should have an intensity of between 100 and 500 candelas.

(3) Indicators are best mounted on the side of a vehicle roughly at the level of the driver's eye. They should emit light forward and backwards and send an appreciable amount of light at right angles.

(4) No consistent evidence in favor of a flashing rather than a steady indicator light of equal intensity has been found and no change in existing practice can be recommended.

(5) Uniformity of type of indicator, position, intensity and rate of flash are important and means for ensuring that standards are adhered to are desirable.

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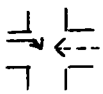
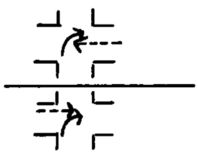
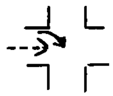
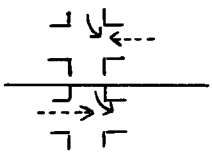
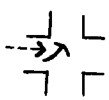
Appendix A

THE MANEUVERS RESULTING IN FATAL AND SERIOUS ACCIDENTS INVOLVING A CAR AT A JUNCTION (1954)

In collisions between a car and another vehicle there are roughly 700 people a year killed and 9,000 seriously injured. In 1954, 5,733 of such accidents occurred at junctions, in 1,653 of which a car was turning, and they are analyzed in the following table. There were comparatively few vehicles fitted with flashing indicators in that year.

Type of Collision[a]	Type of Vehicle Colliding with a Turning Car						
	Other Car	Pedal-Cycle	Motor-Cycle	Goods Vehicle	Public Service Vehicle	Other	Total
1 	89	125	397	23	3	1	638
2 	89	66	261	28	13	4	461
3 	43	14	232	12	2	-	303
4 	24	21	30	8	6	-	89
5 	4	20	31	-	2	1	58
6 Other collisions involving a turning car	10	38	43	12	1	-	104
Total involving turning cars	259	284	994	83	27	6	1,653
Collisions not involving a turning car	640	1,368	1,241	623	181	27	4,080
Total	899	1,652	2,235	706	208	33	5,733

[a]Key Car ——> Other vehicles - - ->

Appendix B

MEAN RESPONSE TIMES OF SUBJECTS TO FLASHING AND STEADY TURN SIGNALS SEEN AGAINST VARIOUS BACKGROUNDS

Conditions of Test		Mean Response Times in Seconds To:					
Time	Background Lights	Amber Ear		Low-Mounted Amber Indicator		Number of Subjects Tested	Number of Responses per Mean
		Flashing	Steady	Flashing	Steady		
Day[a]	Neutral (not operated)	1.41 (1.46) (1.36)	1.48 (1.54) (1.42)	1.43 (1.48) (1.38)	1.40 (1.46) (1.35)	27	162
Day[b]	Flashing	1.33 (1.36) (1.30)	1.29 (1.32) (1.26)	1.42 (1.45) (1.39)	1.38 (1.41) (1.35)	8 repeated 3 times	432
	Steady	1.30 (1.33) (1.28)	1.41 (1.44) (1.37)	1.37 (1.40) (1.35)	1.39 (1.42) (1.36)		
Night	Flashing	1.78 (1.83) (1.74)	2.00 (2.05) (1.95)	2.11 (2.17) (2.05)	2.05 (2.11) (1.98)	20	480
	Steady	1.69 (1.72) (1.66)	1.94 (1.99) (1.90)	1.82 (1.86) (1.78)	1.97 (2.02) (1.92)		
Day	Moving vehicles road test	1.46 (1.54) (1.39)	1.39 (1.47) (1.32)	1.51 (1.57) (1.45)	1.40 (1.45) (1.34)	8	120

(During the static tests by day and the mobile test the rear of the test car was seen; at night the car with dipped headlights was turned to face the subject.)

The means given above are geometric means. The limits of the range of plus and minus one standard error of each are also given in parentheses.

[a]These results have been combined from three tests, the only difference between which was that the angle of separation between the test car and the leveling task was varied (see Fig. 1). Different subjects took part in these three tests.

[b]As above, except that the same eight subjects repeated the test for each of the three angles.

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