Passing Practices of a Sample of Michigan Drivers

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•ONE OF THE most vexing problems to both the driver and the traffic engineer is the passing maneuver on 2-lane highways. Despite the development of the Interstate Highway System and of complex urban transportation networks, 2-lane highways still provide the largest road mileage and almost all drivers pass other cars at some time on a 2-lane road.

The passing vehicle must travel in the traffic lane normally reserved for opposing traffic, and this is cause for uneasiness and sometimes accidents. Steps have been taken to reduce this type of accident and to relieve the anxiety of the driver by warning him when it is dangerous to make a passing maneuver, but these are aids, not guarantees.

Some time ago we began, as part of graduate study, an informal study of passing practices and no-passing zone marking policies. In the course of this research we found that considerable confusion exists about the intent and the interpretation of no-passing zone markings. Therefore, we decided to find out from the drivers themselves how they understood and acted at no-passing zones on the highways.

The study was initiated as a research program towards a Master's degree (1), without financial support of any kind; therefore, the work must be viewed as a pilot study rather than a rigorous analysis of behavioral patterns. The results are more suggestive than conclusive, even though serious staff effort was utilized in the preparation of the study and in the evaluation of the data.

THE PASSING MANEUVER

A driver preparing to pass another car must estimate the time and distance he will be in the left-hand lane until he has overtaken the other car and can return to his own lane (2). He must ascertain that no vehicle traveling in the opposite direction will interfere with his maneuver. Thus, the driver must estimate if an opposing car is far enough away so that he can complete his maneuver before it arrives. If visibility is limited by alignment of the road, the driver must be assured that the distance he can see ahead is long enough so that he could still complete his maneuver without interference if a car should appear. Usually the driver can see far enough and must judge for himself if the distance he can see is sufficient for him to complete his maneuver safely. But there are cases, such as hidden dips in the road, where the driver can be surprised. Furthermore, there are many drivers who do not know how to judge if the available sight distance before a curve or a hill is sufficient for safe passing. For these cases, the traffic engineers have marked no-passing zones on the roads to inform drivers that insufficient sight distance makes passing hazardous.

The foregoing is a very simplified sketch of the purpose of no-passing zones. The actual reasoning and design is complex (3) and outside the scope of this paper, which deals with the relationship of the driver (not, as always in the past, with that of the engineer) to these zones.

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DATA SOURCE

Once the object of the study was determined, a choice of techniques for obtaining the data had to be made. Measurements on the road similar to those done by Crawford (4) were ruled out because of the difficulty and expense involved. Observations of individual drivers in a test vehicle also was impossible for the same reasons. Of the remaining choices, direct interview and questionnaire, the latter was chosen because the cost of interviews would have been greater in time and money, and because a fairly large number of observations were needed, with relatively few variables considered likely to be important.

The questionnaires were self-administered by drivers applying for renewal of their drivers' licenses at six licensing offices in Michigan. The offices were selected for spread in area of the state and rural-urban residence. Two of the areas where questionnaires were obtained are rural and the others are located in central Michigan urban areas of 100,000 population or larger (excluding Detroit). Of course, this does not provide an appropriately controlled probability sampling for these factors, but our resources did not permit a more sophisticated design.

An additional source of bias was introduced in the actual selection of drivers in the licensing offices. In Michigan, drivers' licenses expire every three years on the birthdate of the driver, so a complete enumeration of all persons applying for license renewal in a brief period will yield a sample with birthdate related bias. However, this does not present any problem in this analysis, since we found no reason to expect a relationship between the other variables and actual birthdate over a short cycle of years. Because office supervisors could not require that all persons fill out a questionnaire, coverage is probably not complete and bias might have been introduced.

Development of Questionnaire

The questionnaire was designed in consultation with a group of staff experts on driver training, statistical analysis, traffic engineering, human factors, etc. Several trial designs were actually used on small groups before the final version of the questionnaire evolved.

The practical guidelines for developing the questionnaire were as follows: (a) one page limit; (b) as self-explanatory as possible; (c) sufficiently explicit for any driver to fill out without help; and (d) answers easily tallied, preferably by machine methods. Figure 1 is a facsimile of the questionnaire, showing the percentage distribution of all answers.

The main question complex was concerned with the way each driver acts at a no-passing zone. Because it was difficult to word questions for this section, sketches were used to illustrate certain passing practices, and the question for each sketch asked only if the driver had ever passed in that manner. This type of diagram is used frequently in driver training and testing, accident reporting, and in press and television (5), so it could be assumed that anyone answering the questionnaire would have seen similar material from other sources. (The number of persons who failed to understand the questions here may be some index of the number who do not understand this type of presentation elsewhere). Check boxes were provided for three possible answers for each sketch: "yes," "no," and "only in rare cases." The latter answer was intended to distinguish between habitual and exceptional execution. At least three situations (sketches) were felt to be necessary to distinguish violations of the no-passing zone. The fourth question was included for logical completeness.

Two additional groups of questions were used, one dealing with the characteristics of the respondent and the other with his evaluation of the existing and proposed no-passing zone marking. Both groups were intended for analysis of patterns shown in the passing practices, as well as for independent analysis. The limitation to one page was a severe handicap.

As indicated, the questionnaire was designed for convenient coding and analysis of the answers. An IBM card was punched for each questionnaire. The card deck was then run for totals and distributions of the answers (Fig. 1). Continuous answers (age and driving experience) were each broken into nine discrete groups. All questions

THIS IS NOT AN EXAMINATION

To the Driver:

These questions are asked as part of a graduate research project at Michigan State University. This study is concerned with the driver's understanding of highway No-passing zones. This questionnaire in no way will affect your license renewal. Please help by answering the following questions as they apply to your normal driving habits.

26.83% 72.22% 0.95% NA

1. Have you ever had a class in driver education? yes ☐ no ☐

2.63% NA

2. Sex 61.55% 35.82% Age * Approximate years you have driven * number
male or female years

84.65% 2.12% 12.57% 0.66% NA

3. Do you like to drive? yes ☐ no ☐ depends on time and place ☐

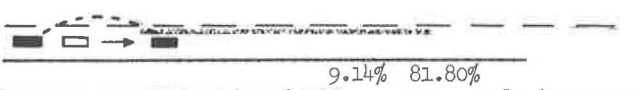
16.45% 92.24% 1.32% NA

4. Do you usually feel uneasy about passing another car? yes ☐ no ☐

5. When approaching a No-passing zone, most drivers know what the yellow line means. We wish to know how the drivers react to this line. In the following sketches, the dotted line shows the path of your car while passing. The solid red line is the yellow line. The dashed line is the centerline. Consider each of the four cases.

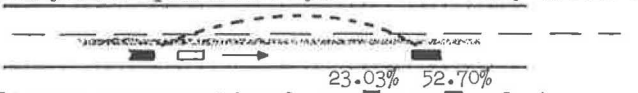
23.61% 34.65% 38.96% 2.78% NA

A. Have you ever passed here? yes ☐ no ☐ only in rare cases ☐



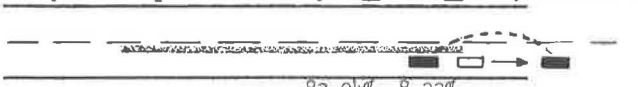
9.14% 81.80% 5.12% 3.95% NA

B. Have you ever passed here? yes no only in rare cases ☐



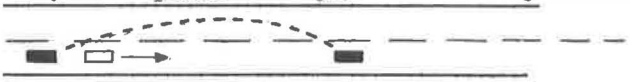
23.03% 52.70% 19.59% 4.68% NA

C. Have you ever passed here? yes ☐ no ☐ only in rare cases ☐



83.04% 8.33% 6.21% 2.41% NA

D. Have you ever passed here? yes no only in rare cases ☐



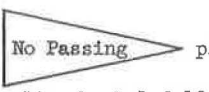
6. When approaching a No-passing zone, which do you notice first (check one per group)

During the daytime:			During the night:		
a. The yellow line	☐	49.49%	a. The yellow line	☐	36.55%
b. The Do Not Pass sign	☐	45.47%	b. The Do Not Pass sign	☐	54.39%
c. I don't know	☐	5.04%	c. I don't know	☐	8.85%

7. Do you feel that the present system of marking No-passing zones is adequate?

78.00% 19.23% 2.78% NA

yes ☐ no ☐

8. Would a large yellow sign like this one 

placed on the left hand side of the road, at the start of the yellow line be helpful?

68.86% 28.72% 2.92% NA

yes ☐ no ☐

*Not in suitable form to be placed here.

THANK YOU FOR YOUR TIME

Figure 1. Questionnaire, showing response percentages.

were then compared numerically against all other questions in a bivariate analysis by computer. After these results had been evaluated and discussed, we analyzed certain

interesting answer patterns again as to the characteristics of the respondents in the pattern. Passing practice patterns especially were analyzed this way.

Discussion of Sample

A total of 1,368 completed questionnaires were collected. One of the first items to be investigated was the correspondence of the sample to population or to other sampled groups. Inquiries were made of a number of organizations and agencies possessing comparable statistics. It was especially hoped to get national or at least large group averages for age, sex, and driver training.

Age distributions were available from several states (6-10) on samples much larger than the one considered here. Figure 2 shows these age distribution curves plotted year by year. All curves, even those representing large samples, exhibit some irregularities, probably due to local differences and methods of compilation. This might be corrected by a horizontal shift of the curves to adjust for age spread. The sample of Michigan drivers show an irregular curve partially explained by the three-year duration of the driver's license, which brings the drivers back for renewal in multiples of three years from the time of their first drivers' licenses. Since licenses can be obtained at age 16, the peaks at ages 19, 22, 25, 28, etc., were predictable. The dip around age 31 is similarly explicable.

Considering an averaged curve for the Michigan sample, one still finds a tendency for more drivers in the younger than in the older groups. This could be either a characteristic of the respondent population or a bias in the sample, perhaps caused by older drivers being more reluctant to fill out the questionnaire than younger drivers.

Figure 3 shows the age distribution by sex for the national total as assembled by the National Safety Council (10), the Illinois sample (9), and the Michigan sample (5-year plots). It can be seen here more clearly that the Michigan sample contains more drivers in the younger age groups for both sexes. Male drivers show a larger than national average percentage up to the middle thirties, while female drivers predominate only in the teens and lower twenties.

Table 1 indicates that the distribution of all drivers in the sample by sex shows the same breakdown for the Michigan sample as for two other states and the nation as a whole. Only New York has a substantially larger proportion of male drivers than the

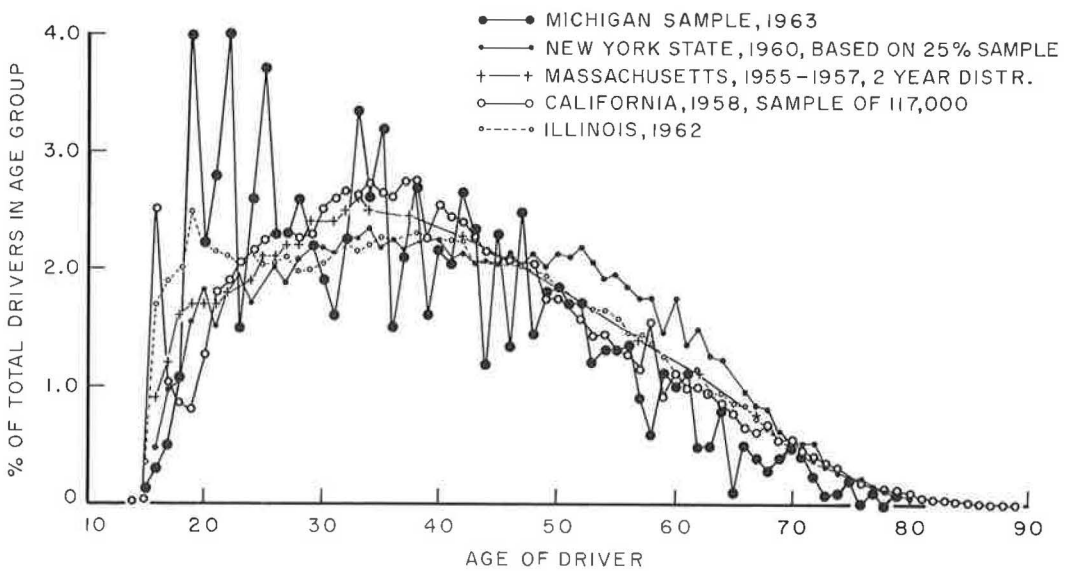


Figure 2. Driver distribution by age.

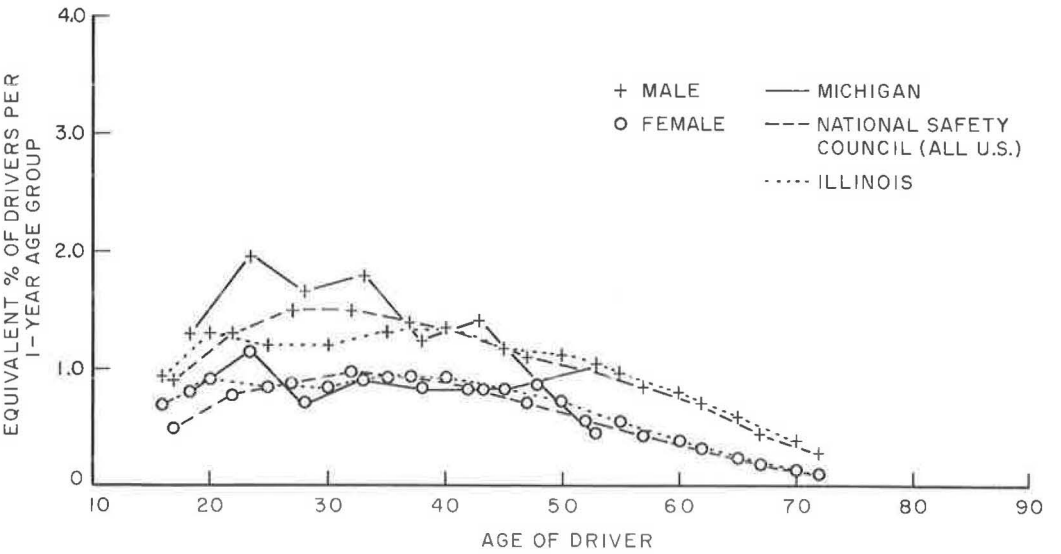


Figure 3. Driver distributions by age and sex.

other samples. The good correlation of the Michigan sample with the national average indicates that if any bias exists in the Michigan sample, it is shown evenly in both sexes.

DRIVER'S CHARACTERISTICS

The first four questions in the questionnaire deal with the general characteristics of the driver: sex, age, and driving background (years of driving experience, driver education, opinion about driving and passing). The locality where he renewed his license was also coded on the form.

One of the most surprising facts is that 85 percent of the respondents in the sample like to drive (Fig. 4). More surprising is that only 2 percent state flatly that they do not like to drive. Even considering the likelihood of improper motivation of the respondents at the time of filling out the questionnaire, the magnitude of the response is overwhelming and suggests that further study of this question is needed. Only nine respondents (less than 1 percent) did not answer this question, making it one of the most complete answers in the form.

The question concerning uneasiness about passing (Fig. 5) also provided a surprising answer, although it was in keeping with the responses given previously. Only 16 percent of the drivers answering the questionnaire feel uneasy about passing, 82 percent do not feel uneasy, and only 1.3 percent did not answer the question at all.

TABLE 1

DISTRIBUTION OF DRIVERS BY SEX

Sample	Year	Total No.	Male		Female	
			%	No.	%	No.
Michigan	1963	1,368	63	842	37	480
California	1958	117,201	61	71,992	39	45,209
Illinois	1962	4,690,467	61	2,848,972	39	1,841,495
New York	1960	7,006,206	68	4,782,072	32	2,224,134
Nat. Safety Council	1962	91,000,000	63	57,000,000	37	34,000,000

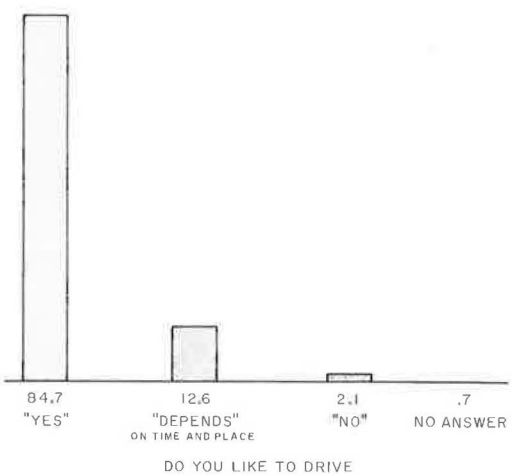


Figure 4. Distribution of response to Question 3.

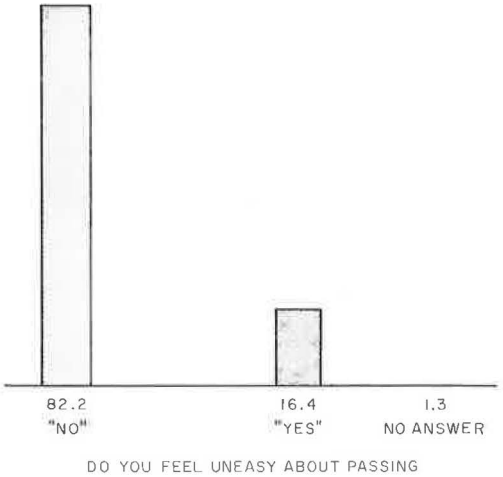


Figure 5. Distribution of response to Question 4.

An analysis of these two characteristics was expected to clarify the relationship between feeling uneasy about passing and not liking to drive. Since the passing maneuver on a 2-lane highway represents one of the most hazardous operations in driving, we expected a close link with dislike of driving. From this point of view, the following results of our questionnaire are especially interesting.

A distribution of the responses into each of the six cells formed by a matrix of the two variables is shown graphically in Figure 6. With the predominance of positive responses, any relationship between uneasiness about passing and not liking to drive is rather unimpressive, even though it can be shown to be statistically significant at levels commonly used in survey analysis. With this limitation in mind, it can be fairly concluded from the combined responses of the two items that there is a strong possibility that uneasiness about passing may contribute to the dislike of driving. One out of every 3 drivers who do not unconditionally like to drive feel uneasy about passing, whereas only 1 out of every 8 who like to drive feels uneasy about passing. It should be emphasized that the data also indicate that other factors contribute more to the dislike of driving. This should be of considerable interest to driving teachers and law enforcement officers.

The same questions about passing and driving were also compared to all other variables analyzed in the questionnaire. Selected values of these analyses are shown in Figures 7 and 8. The values given here include maximum and minimum relations as well as some values where relationships might be considered of interest. It must be noted that in many selected categories, the sample frequency is very small. The numbers of responses on which the distributions are based are given at the top of each column. The reader may judge for himself the significance of each distribution.

The variations in liking to drive are reasonable and predictable. The small proportion of teenage drivers who do not unconditionally like to drive (one-third of the general proportion) could be expected, considering the newness of the experience and the general enthusiasm of that age group—particularly for driving. It might also be important that teenagers generally do not have to drive and those who do not like it may not learn to drive until they need to.

A similar variation exists in the distribution of drivers who feel uneasy about passing in relation to other variables (Fig. 8). The highest increase, almost threefold, is in the group who do not like to drive. This distribution might serve here as a warning about the potential misinterpretation of this type of result. It might be pointed out that more drivers who have had driver education feel uneasy about passing. Of the drivers who do not know which of the no-passing zone markings they see first, almost twice as

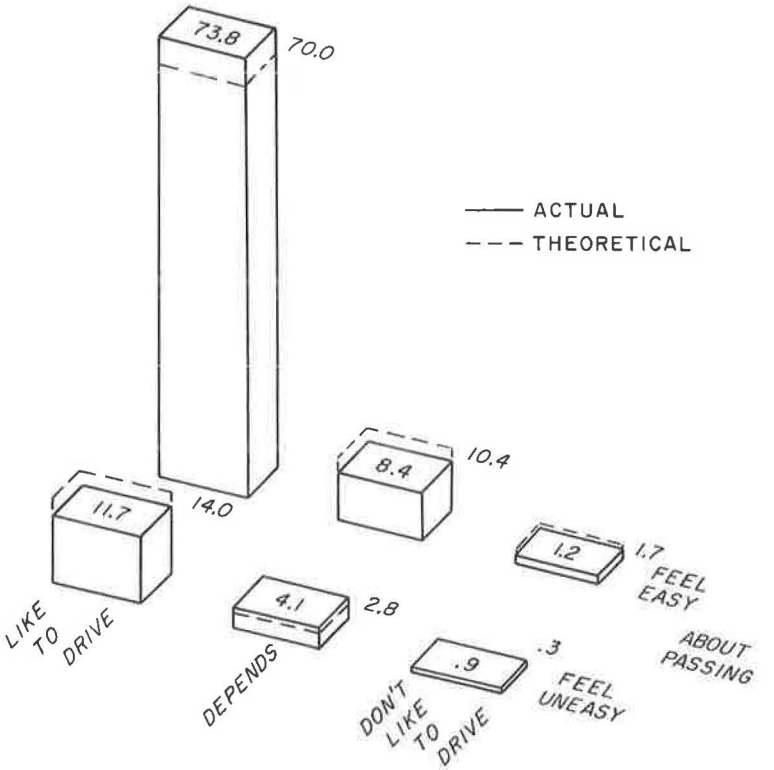


Figure 6. Correlation of opinions about driving and passing.

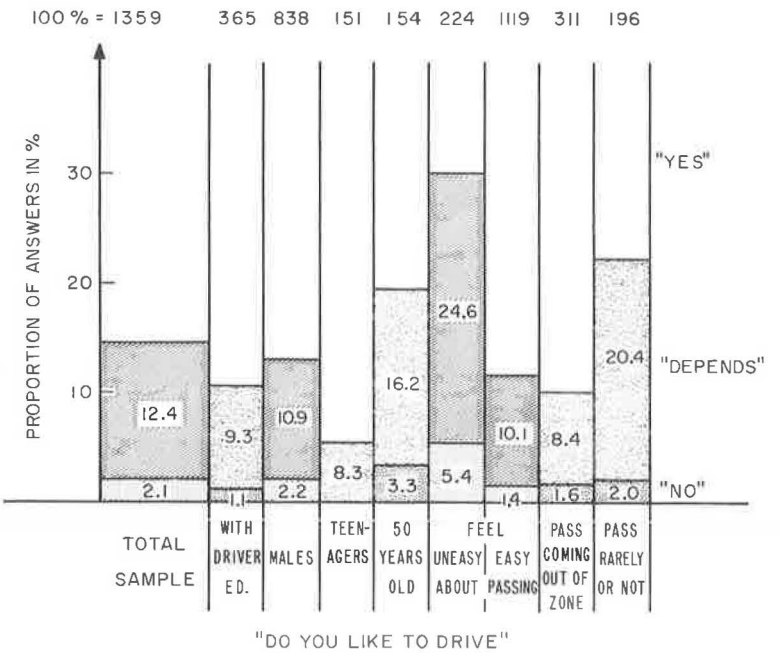


Figure 7. Not "liking to drive" as percentage of selected other distributions.

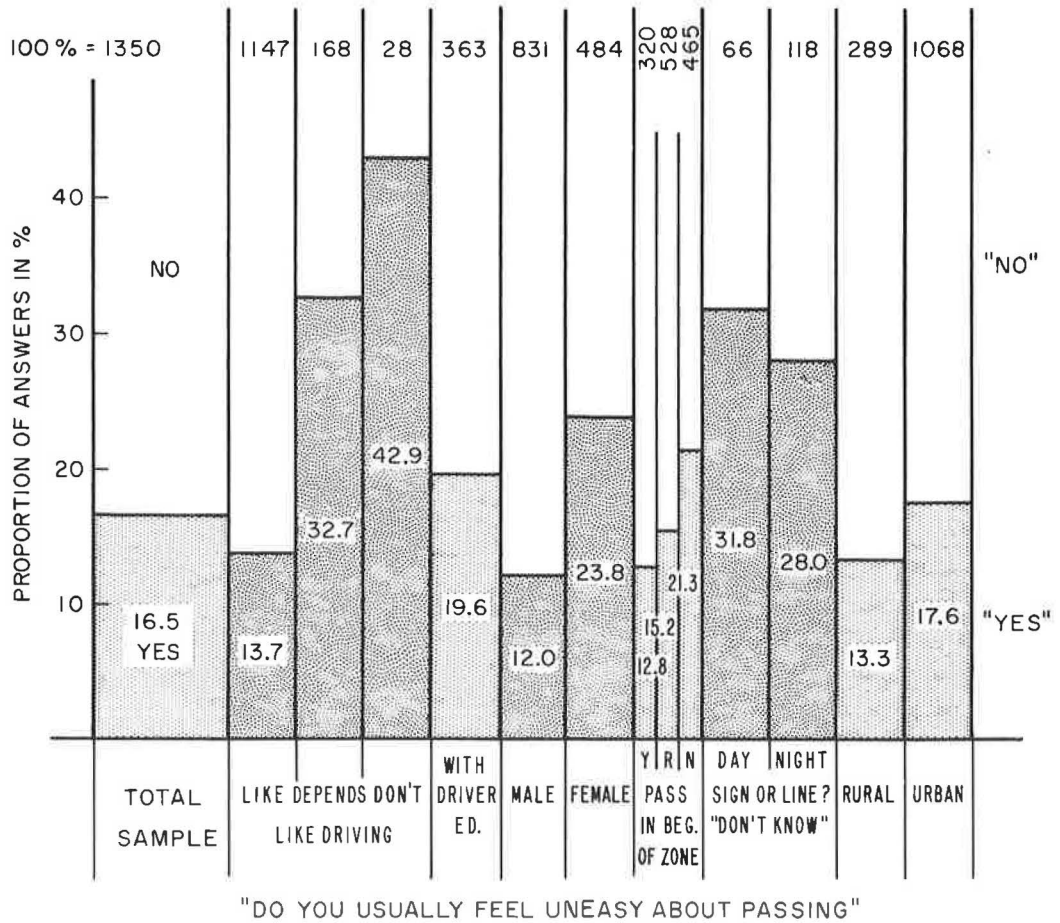


Figure 8. Feeling "uneasy about passing" as percentage of selected other distributions.

many feel uneasy about passing during both day and night. This might be a significant relation, although it might be hard to relate definitively to driver education or to driver personality. It is also reasonable that the proportion of respondents who feel uneasy about passing is much lower for males than for females. In relation to the behavior in no-passing zones, only small indications are found. For instance, of those who pass near the beginning of a no-passing zone and cross the beginning of the yellow line, a smaller percentage feel uneasy than of those who do not pass there. An interesting result is obtained when comparing rural to urban areas. The lower percentage of rural respondents who feel uneasy about passing may be explained by the greater necessity for passing in rural areas. But this conclusion should be accepted with reservation, since there are many other variables which could underlie this relationship; for example, the two rural areas sampled for this study provide fewer young respondents than the other localities.

Another interesting fact in these general driver characteristics is shown in Figures 9 and 10. Figure 10 shows a decided predominance of females with shorter driving experience; males generally learn to drive at an early age and females apparently learn to drive at all ages. This leads to the conclusion that the percentage of female drivers increases over the years, which is supported by Figure 9 showing the decided change in ratio between male and female drivers by driving experience and the essentially constant ratio by age.

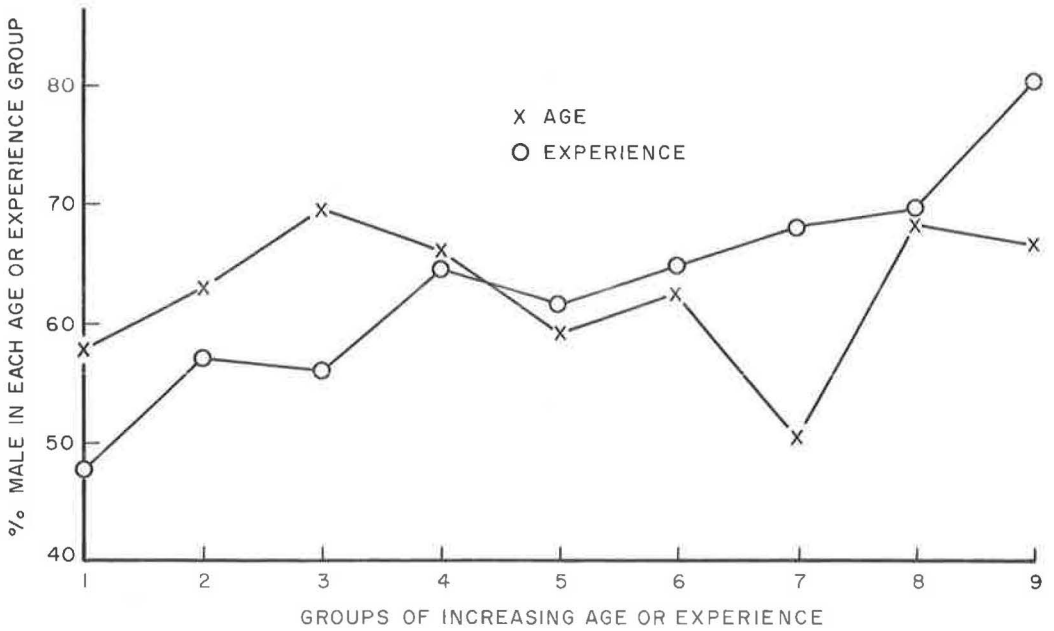


Figure 9. Percentage of male respondents by driving experience and age.

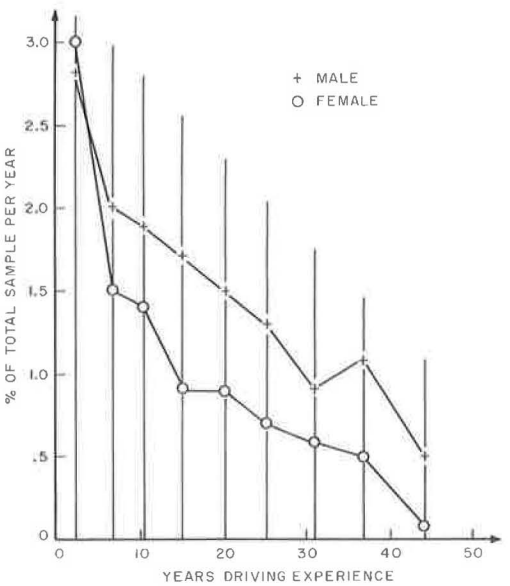


Figure 10. Distribution of male and female drivers by number of years driving experience.

Figure 11 shows the percentage of drivers with driver education by age groups. The strong drop represents the effect of the introduction of compulsory driver education in Michigan schools in 1956.

Reaction to No-Passing Zone Marking

The last three questions in the questionnaire concerned no-passing zone marking practices and their acceptance. Since in Michigan no-passing zones are marked with a yellow line on the pavement, as well as roadside signs both at the beginning and at the end of the zone, we first intended to find out which of the two markings the drivers judged more effective. Surprisingly enough, both types of markings appear to be almost equally noticeable, with the signs having a slight advantage at night. Most surprising was the small response in the uncertain category. Only 5 percent admit they did not know which of the two markings they notice first. The uncertainty rose to 9 percent at night. Approximately one-third of the respondents switch from one type of marking to the other between day and night. Figure 12 illustrates that 23 percent switch from line to sign, only 12 percent switch from sign to line, and the increase in the "don't know" answer comes from both types.

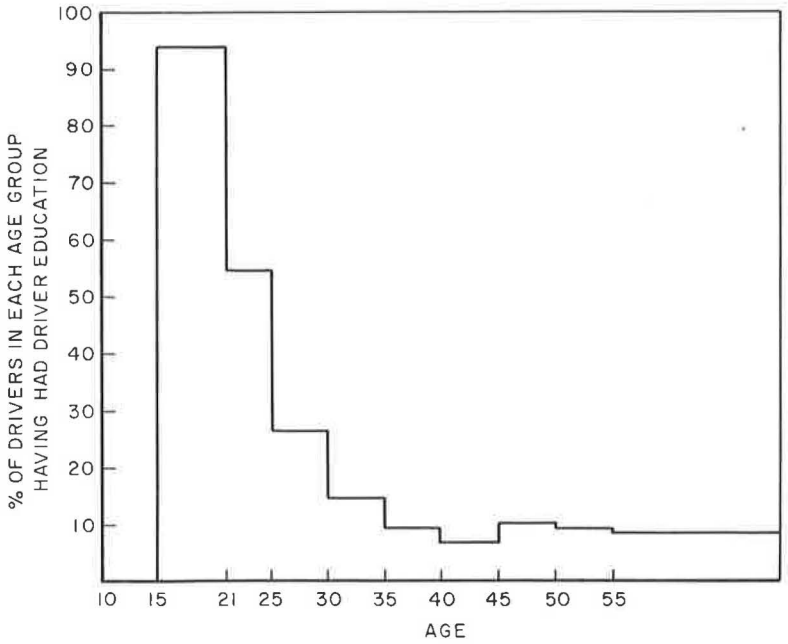


Figure 11. Driver education percentage vs age.

The split of the answers and the low occurrence of indefinite answers is remarkable, but it cannot be concluded that one type is better than the other, nor can it be said that both are needed. The only conclusion is that both markings seem to be almost equally noticeable. It is not surprising, then, that an overwhelming 80 percent of the respondents feel that the marking is adequate. Even 80 percent of those who do not know which they notice first, the sign or the line, feel that the present system is adequate.

The last question in the form, dealing with the large sign introduced by the Iowa State Highway Department, is more informative. Even though 80 percent of the respondents feel that the present marking system is adequate, about 70 percent still feel that the Iowa sign would be helpful. Of those who are dissatisfied with the present marking system, only 87 percent feel that the Iowa sign would help.

The significance of these results lies in the fact that no marking system for no-passing zones seems to be generally preferable. The preference for line and sign is almost evenly divided. The possibility of an Iowa-type sign with its generous size and its conspicuous placement on the left side of the roadway does not appear to generate overall enthusiasm. This result seems to be the more remarkable to the engineer, since each of these marking practices is clear-cut and should be expected to produce a definite preference pattern.

PASSING CHARACTERISTICS

The response patterns given by drivers to the four questions dealing with passing practices are analyzed together, producing various passing patterns of driver behavior. These patterns are considered from two points of view: (a) the engineering or design intention is used as a basis for comparing the patterns, and (b) the patterns themselves are compared to other driver characteristics in an attempt to find possible relationships.

In each of the four questions concerned with passing practices, the drivers in our sample were offered three answers from which to choose: "yes," "only in rare cases," and "no." Another response to each of the four questions could be, and was

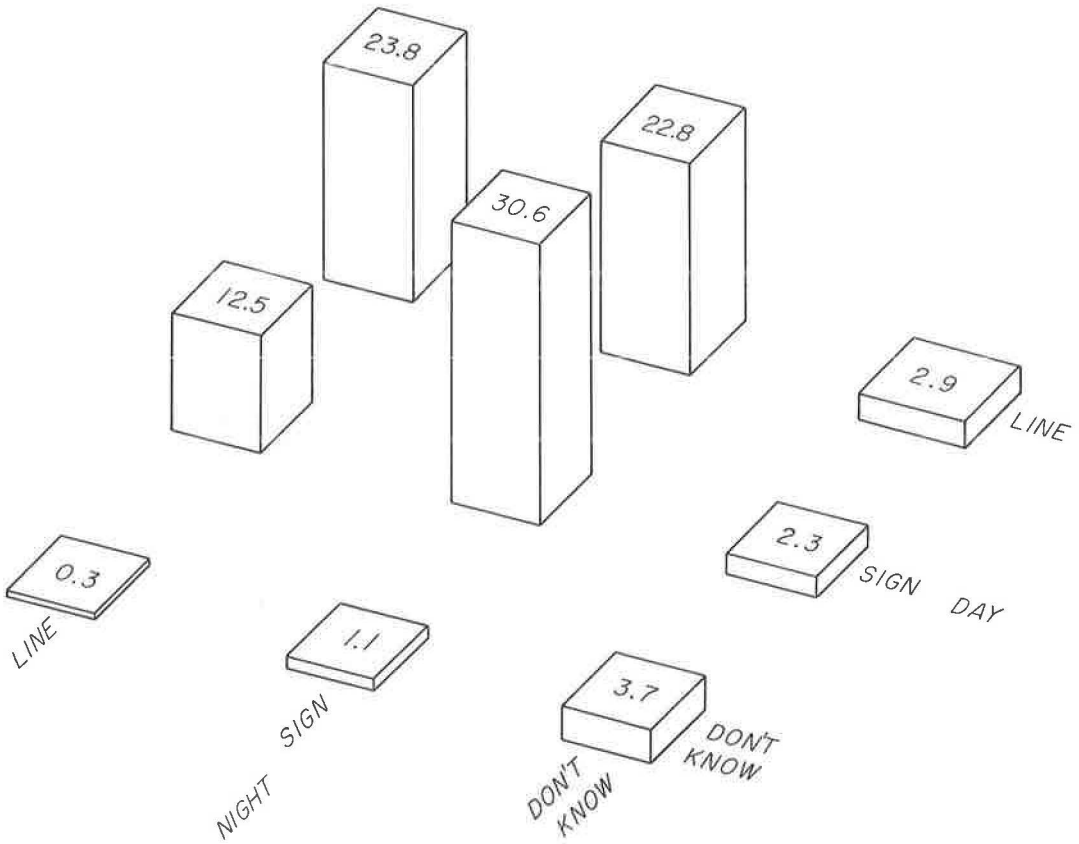


Figure 12. Shift of recognition of sign between day and night.

made, by not checking any of these answers. Of the 1,368 drivers in our sample, 108 (7.9 percent) did not check an answer to one or more of the questions on passing. Failure to answer some passing question(s) was not found to be substantially associated with answers checked on other passing questions; consequently, all 108 were eliminated from further analysis.

For the remaining 1,260 drivers, there were four questions with three possible answers to each, yielding a total of 81 possible (permutations of) response patterns. (Of these possible patterns, 63 actually occurred.) Not all of these would be expected since some order should be anticipated; for example, a driver's answers of "yes" for passing entirely within a zone, and "no" to the other three questions on passing make no sense. Possibly, he may have misunderstood the diagrams used to show the passing situations or the regulations for no-passing zones. However, these drivers were applying for license renewal, and to receive a license, they had to have shown knowledge of no-passing zone regulations. Given the actual wording of the questions, such unexpected (or illogical) response patterns may be correct reports of drivers' behavior, but this possibility does not present a methodological problem of the sort considered here and is generally ignored in the sequel.

Passing Patterns vs Engineering Intentions

A summary illustration of the answers is given in Figure 13. At first glance it appears that there is an overwhelming response of correct answers considering the shaded responses as correct. The answer "only in rare cases" may be considered

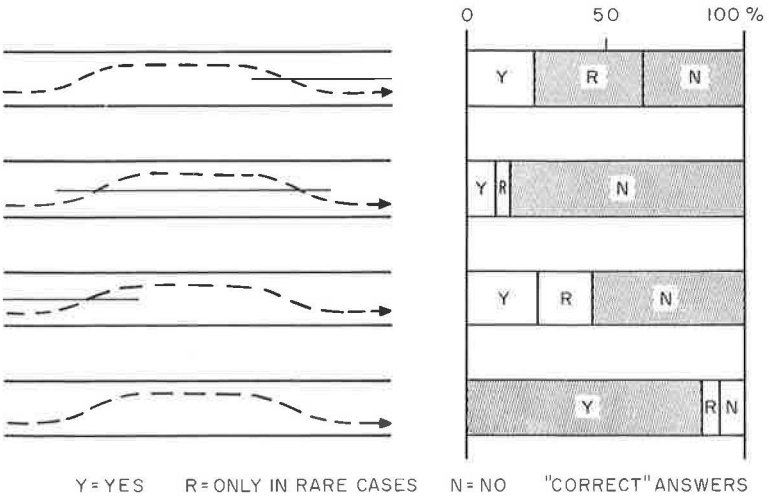


Figure 13. Distribution of responses to passing practice questions.

correct for the driver crossing the yellow line when entering a zore, but it cannot be accepted as readily in the next two questions, where it represents a voluntary action of the driver. It appears from the figure that in all cases the correct answers are more than 50 percent, but this a gravely misleading conclusion, since only the combination of all four correct answers is truly correct driving practice. The view of the frequency of combinations of answers given in Figure 14 indicates that only 424 respondents (30 percent of the sample) give this correct answer. Taken at face value, this is a shockingly low number of drivers who claim to observe no-passing zones according to enforcement intentions.

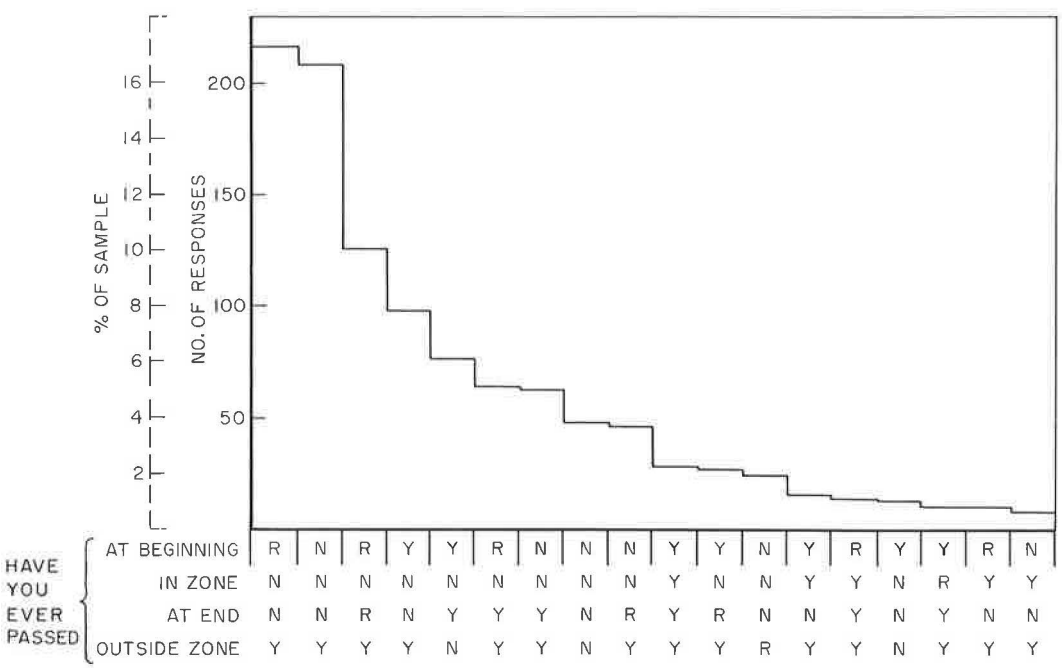


Figure 14. Passing practice response patterns (in descending order of magnitude).

It is surprising, too, to find such wide divergence in the answers and to get so many answers in incorrect answer patterns. As stated above, there are 81 possibilities, of which 63 were given by one or more of 1,260 respondents. This fact in itself is rather disturbing, if one accepts that the questions were answered seriously. It points up the possibility that there is a great variety of misinterpretations (regardless of the number of responses in each pattern) among the driving population represented by this sample. Although this problem is not further explored here, it should be recognized and remembered when analyzing odd driver behavior or a freak accident.

Further analysis of Figure 14 shows some other relatively frequent patterns. Some of these seem to be related and have been grouped as shown in Figure 15. The second of these groupings alone contains 307 responses. This group consists of those people who will violate the end of the yellow line, probably because they believe that they can see far enough ahead. This is a serious misunderstanding since the zone is laid out based on actual visibility, but with a distance shorter than the full passing distance required from the start of the maneuver. Thus, passing is sometimes not even safe at the end of the line, let alone before. But the response is understandable, especially when a driver who has been trailing another vehicle for some time sees another no-passing zone coming up. This pattern with its sizeable representation should be cause for concern for driver educators and highway design engineers.

We included in this grouping all "yes" and "rare" responses to the third question (passing at the end of the zone), and all "no" and "rare" responses to the first question (passing at the beginning). This is based on the reasoning that a rare violation of the beginning of a zone is assumed to be involuntary; i.e., a driver thought he had enough distance to complete his maneuver before the zone but could not. When violating the end of the zone, however, the action is strictly at the driver's discretion and "rare" violations are still voluntary.

The next group comprises those drivers who freely violate both ends of the no-passing zone. This group, containing three patterns with a total of 117 respondents,

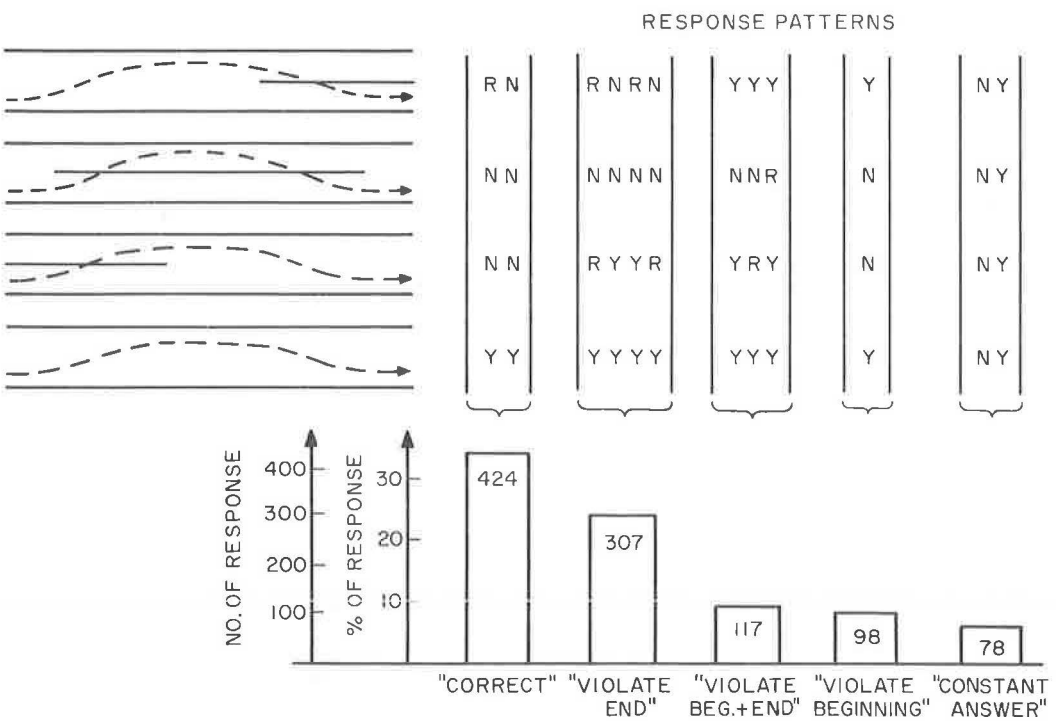


Figure 15. Major passing patterns.

is almost 10 percent of the sample. Another misinterpretation of the zone is made by those drivers who will freely violate the beginning of the zone but will not pass within or at the end of the zone. Only one pattern is included, with 98 respondents who apparently misinterpret the no-passing zone markings to mean that they cannot initiate a passing maneuver but can safely complete it within the zone. It is interesting that the group who never pass or always pass is so large, amounting together to almost 6 percent of the sample.

Passing Patterns as Behavioral Scale

In general, if we assume that the three possible answers are ordered from "yes" through "only in rare cases" to "no," then answers to all passing questions should be at least as positive as the answer to passing entirely within a no-passing zone; none of the other answers should be less positive than the answer to passing within an unzoned area. With this restriction it can be shown that there are only 20 logical combinations of answers to the four questions. In terms of behavioral science conventions, we are arguing that answers to these questions ought, a priori, to form a partial Guttman scale; i.e., the second and fourth items should form the extremes, while the first and third items form the means, but are not necessarily ordered between themselves (11).

In empirical examination of the data, it developed that an even stronger order can be made in which the relation between the first and third items is specified. However, this was not specifically anticipated in the research and constitutes a serendipitous result.

Each of the 20 logical patterns—ranging from "yes" to all four questions to "no" to all four—was actually reported by some drivers, though in greatly varying frequencies. Of the 61 illogical patterns, 43 were actually reported by some drivers. (The most frequently reported illogical pattern was chosen by 16 drivers, or about 1.3 percent of the 1,260 who gave complete answers.) Of the 1,260 drivers involved, 166 (about 13 percent) gave illogical answer patterns.

This substantial proportion of illogical responses raises a problem as to the efficacy of the questionnaire in eliciting true responses from the drivers and again points up the tentative nature of the data we are examining. At the same time, the fact must not be overlooked that nearly 87 percent of those who gave usable answers gave logical responses, and, as will be seen later, substantial proportions of these fall into predictable patterns.

The essential question raised by the illogical patterns is whether the logical patterns are to be regarded as true answers, or whether these could have been obtained by chance. A gross estimate of this possibility can be obtained by calculating the chi-square test of the goodness of fit of the actual frequencies of logical and illogical patterns to the expected frequencies, calculated on the assumption that the answers a driver gave were independent of each other. Without reproducing the calculations here, it may be stated that the null hypothesis, of no relation between the answers to the passing questions, may be safely rejected.

This does not eliminate the possibility that logically correct patterns of answers may have been given by some drivers who did not understand the questions. However, examination of the frequencies of the illogical patterns suggests that drivers who did not understand the questions did not choose any particular patterns. In other words, they misunderstood the questions in different ways and the responses were generally randomized. It seems reasonable to suppose that the same randomizing effect would be observed among the logically correct responses if we were able to interview the drivers involved to obtain corrected data. The general consequence of such randomization would thus be to attenuate any relationships that actually existed between the patterns of answers to the passing questions and the other variables examined. We feel reasonably confident that any bias in the data is actually conservative and probably tends to underestimate real trends.

Therefore, we determined to examine the most frequently reported logically correct patterns of response and their relations to other variables. Of the 20 possible

patterns, 7 had low frequencies (the highest was 9) and together accounted for only 43 drivers. These and the logically incorrect patterns were eliminated from subsequent comparisons, leaving 1,051 drivers for analysis. One of the remaining 13 patterns had only 12 responses, and was grouped with a nearly identical pattern. There remained 12 logically correct patterns which are shown in Table 2 with the number of drivers reporting each pattern and other selected statistics. Each pattern has been assigned a type number to facilitate references.

In reading the summary data shown in Table 2 and the discussion, several points should be kept in mind. As noted in the preceding section, there is a wide variation in the number of drivers reporting each pattern; the most frequent pattern (Type 7) is given nearly 10 times as often as the least frequent (Type 11). Smaller samples usually will be less stable as estimators. Also, median values given to show central tendencies of the associated distributions are central values and do not show the spread about the point. (The variances are substantially homogeneous throughout and have not been included here.) Medians have been used rather than means or modes because they are less sensitive to skewness and other irregularities. Percentages are based on the number of drivers in the type less any who did not answer the question. Unless otherwise noted in the discussion, judgments of the strength (or significance) of relations with other variables are based on examination of the chi-square test of independence for bivariate frequency distributions.

The patterns are ordered substantially by decreasingly positive responses to the passing questions. These agree regularly with decrease in the number of males and increase in the median age for drivers reporting each pattern. The ordering was actually determined by examining the relationship between the patterns and other variables to discover what ordering provided the best prediction and retained a manifestly sensible relation among the patterns. As noted previously, the placement of responses to the second and fourth items (positive and negative at beginning and end, respectively) was as constructed, but all expectations about the first and third items were ambiguous. For a given response on the first item, the order of the types is in decreasingly positive response to the third item. The only anomaly in this ordering is Type 2, which might be thought to belong between Types 5 and 6. It has been placed second because of the close agreement with overall ordering of median ages. It is interesting that in Type 2 is the strongest evidence that violation of the end of the zone is regular rather than occasional, based on the fact that all three possible answers to the four passing questions were used.

The patterns show what the drivers report they have done, but two different drivers who have actually passed in the various situations with about the same relative frequency may give slightly different reports, depending on how they answer questions. Some persons, particularly, tend not to use middle alternatives, such as "only in rare cases;" for example, two different drivers might give Types 8 and 9, respectively, but drive in essentially the same manner.

TABLE 2

PASSING PATTERNS AND OTHER CHARACTERISTICS

Type	Begin	In	End	Out	Freq.	Male (%)	Median Age			Driver Educ. (%)	Median Years Driven	Like to Drive, Uncond. (%)	Uneasy Passing (%)	No-Passing Zone Approach (%)				Marking Adequate (%)	Iowa Sign Helpful (%)
							Male	Female	All					Day		Night			
														Line	Sign	Line	Sign		
1	yes	yes	yes	yes	29	83	26	40[a]	28	38	12	86	21	59	38	48	45	69	62
2	rare	no	yes	yes	65	77	30	30	30	31	13	94	15	42	57	23	69	71	66
3	yes	–[b]	yes	yes	89	84	32	32	32	38	15	90	9	56	38	43	51	74	75
4	yes	no	rare	yes	28	68	32	32[c]	32	25	15	96	4	68	29	43	50	67	85
5	yes	no	no	yes	98	76	30	34	31	28	13	87	12	58	38	37	57	72	75
6	rare	no	rare	yes	132	68	34	34	34	29	17	88	21	57	40	40	55	78	79
7	rare	no	no	yes	216	71	33	36	34	26	16	85	11	52	43	40	51	82	66
8	no	no	yes	yes	65	56	39	35	38	19	19	92	18	40	54	17	70	83	72
9	no	no	rare	yes	47	49	41	38	39	23	19	85	19	62	34	45	49	83	77
10	no	no	no	yes	208	52	41	35	38	28	16	84	21	42	51	28	61	87	62
11	no	no	no	rare	25	64	39	44[c]	41	20	12	76	24	28	64	36	56	79	63
12	no	no	no	no	49	38	45	42	43	23	18	80	32	51	45	49	45	83	64
Total					1,051	66	34	36	35	28	16	87	17	51	44	36	56	79	70

[a]Based on frequency of only 5.

[b]Divided between "no" and "rare".

[c]Based on frequencies less than 10.

Passing Patterns vs Age and Sex

The agreement of the ordering of the patterns with age and sex of the drivers is quite striking and is within the range of plausibility based on a priori expectations about driver behavior (given that the reported patterns as such are not really unexpected). A gross measure of the relationship can be obtained from the product-moment coefficient of correlation. The value of the coefficient for the patterns is with age 0.21 and with sex 0.23. The last five types have lower proportions of males and higher median ages than any of the preceding seven types. At the same time it must be repeated that in each pattern there is a spread of ages not included in Table 2. This partially accounts for the low correlation coefficient, but the spread is expectable. On the whole, the relation between the patterns and age is linear. The data seem to confirm what many might suspect; i.e., women are more cautious than men, and people become more cautious as they grow older. This seems most plausible, but it should not be overlooked that differences in driving patterns in relation to age might be due to changes in typical driving habits of new drivers, with fairly constant habit patterns persisting through adulthood. Neither the spread within patterns nor the situation with respect to number of years of driving experience confirm this. It is unlikely that really conclusive evidence can be found without a longitudinal study. The relation of the patterns of sex is not as straightforward as with age, but there is even more gross difference in the numbers of males and females reporting each pattern.

It is worthwhile to speculate on the meaning of the ordering of these patterns, remembering that we have no supporting evidence from direct questions. It is possible that the order reflects decreasing intent to violate the purpose of posted no-passing zones. The relationship of the pattern ordering to age and sex agrees with this, in that we usually expect more conservative and cautious behavior from women and older persons. This interpretation would be supported if drivers on the whole believed that violation of the beginning of a zone is more serious than violation of the end. This is not implausible since those who do not answer "no" to the third passing question include "peekers" (drivers who begin edging out of their lane when approaching the end of a zone in order to see ahead, believing that they will have ample opportunity to return safely, and who do not intend to decide on passing until out of the zone). But they do not cross the line accidentally. On the other hand, at least some of those who report violations at the beginning of the zone have done so unintentionally in their own view. It is possible that there are actually fewer who intentionally cross the beginning of the zone line than there are who intentionally cross the end of the zone. Furthermore, from the viewpoint of driver psychology, it seems quite likely that violation of the beginning when danger is approaching is more serious than violation at the end when danger is receding.

The questions ask what the drivers have done but do not elicit their opinions about this behavior or their reasons for it. This, of course, constitutes an unresolved problem which should be pursued further, since the ordering of seriousness of beginning and end violations of no-passing zones is the reverse of the actual logic (with regard to unimpeded sight distance) on which zone marking is based. If this is true, it is an important area for continuing driver education.

Passing Patterns vs Other Characteristics

Other items on the questionnaire elicited information about the drivers' training, attitudes toward driving, and experience with and opinions about marking of no-passing zones.

The patterns of passing behavior do not appear to be related to the training and experience of these drivers, i.e., there is no strong relationship between these patterns and the question, "Have you ever had a class in driver education?" We do not take this lack of a simple direct relationship as evidence that driver education does not have an effect on passing behavior; it seems more plausible that other factors confound the relationship. There is a relationship between the patterns and the number of years the person has been driving (correlation coefficient = 0.11), but this may be accounted for by the stronger and expected correlation between number of years of driving

experience and age. In fact, by controlling for age, the partial correlation coefficient between years of driving experience and the passing patterns is -0.16; i.e., the relationship is inverse. In Table 2, this negative relation is exhibited in decreasing median ages within each subset of patterns with same responses on the first passing question, with the exceptions of Types 1, 2 and 12. This suggests that there may be some tendency for drivers to become less cautious with increased experience.

In regard to the attitudinal question, "Do you like to drive?" there is no evidence of notable relation between the answers and passing behavior. There is evidence of a statistical relationship between uneasiness about passing and patterns of passing behavior, but the general meaningfulness of this is obscure. Those who never violate a zone are more likely to feel uneasy than others. However, in all patterns except Type 12, more than three-fourths answered "no" to the question. This relatively high proportion of uneasiness about passing among those who answer "no" to all passing questions may seem to be in error, but it must be remembered that the questions were only about 2-lane highways.

With respect to zone markings, the passing patterns are more related statistically to experience than to opinions, but again without meaningful detail. There is a tendency for those who do not violate the beginning of the zone to report seeing the "Do Not Pass" sign—during both day and night—more frequently than others. The increase in preference for the sign at night holds for all patterns except Type 11. The opinions about adequacy of marking and use of the Iowa sign are not strongly related to the patterns, but in each case there is a consistent relation. The first types are less likely to consider zone markings adequate, and the extremes less frequently think the Iowa sign would be helpful.

Taken overall, there are clear indications in the data that personal characteristics expressed as demographic factors are significantly related to the patterns of passing behavior analyzed. The present research only permitted inclusion of information about age and sex of the drivers. In future study it would be extremely valuable to gather data about the social and economic status of the drivers, amount of formal education, occupation, and place of residence in rural or urban area. (This last factor was largely excluded from our analysis, because the information was only grossly available in terms of the office where the license was renewed.) Also, additional information should be obtained about the kind and amount of past and current driving experience. It is not to be expected that these factors would completely account for the differences in passing behavior, let alone other driving habits. However, they could provide indications about the kinds of drivers who need education and reeducation in safe driving practices.

Similarly, much more information is needed with respect to the suggestions about drivers' opinions on the relative seriousness of infractions. Such study could provide useful guides to the focus of content in safety propaganda.

CONCLUSIONS AND RECOMMENDATIONS

This pilot study on driver passing behavior on 2-lane highways must be viewed as suggestive rather than conclusive, but many results are obtained which point to the need for further investigation related to both engineering design and driver education.

There is striking evidence of relatively low frequency of what might be called correct driving in no-passing zones; in particular, almost a quarter of the sample appear to violate the beginning, and almost half the sample the end, of the no-passing zone.

Examination of the overall patterns of passing behavior gives evidence of a much wider variety of actual behavior than may be anticipated in design for typical, average, or ideal patterns of practice. The observed relationship between this particular aspect of driver behavior and the demographic information on sex and age suggests the desirability of further study of a wider range of demographic factors, since discovery of substantial relationships could have most useful consequences for efforts to improve driving practice.

Further examination of the patterns themselves leads to the possibility that drivers may make substantially different interpretations of the meaning of zones than do those

who design them. The observed—but sometimes anomalous—relations between the patterns of passing and other variables studied provides a challenge for further investigation.

The abundance of interesting and surprising results which come from this small study points out the great need and justification for further, more detailed work in this area, with larger samples and better control. Only then can this pilot effort have served its true purpose.

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