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Drivers' perception of right-of-way at uncontrolled T intersections

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Drivers' perception of right-of-way at uncontrolled T intersections

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INTRODUCTION

The use of STOP and YIELD control at intersections is a subject of great concern to engineers with traffic and transportation responsibilities. Overly restrictive control of traffic may result in excessive air pollution, excessive energy usage, and unnecessary delay to motorists. On the other hand, control that is not restrictive enough may result in unsafe operation at an intersection. This unsafe operation may appear as simply a large number of vehicle conflicts, or it may appear as a higher than expected accident rate.

There is a growing concern among traffic and transportation engineers that STOP control is being overused, and that drivers are increasingly choosing to ignore STOP signs. While it is true that warrants exist for the use of STOP and YIELD signs (24), the use of "political" warrants to justify their installation has focused attention on the need to define more clearly the circumstances in which these devices are effective and to develop an improved set of warrants for their use.

An important consideration in the development of appropriate warrants for STOP and YIELD control at intersections is related to the location of the intersection. The intersections most likely to be uncontrolled are those in rural areas on low-volume and very-low-volume roads. This implies that any guidelines for controlling these intersections will have significant impact on the budgets of county engineers, at least in the State of Iowa. If some conflicts are more likely than others to result in accidents, it is possible that these are also more likely to result in tort liability claims against the government agency having jurisdiction over the intersection. In view of the large potential cost of tort liability, it would certainly be of interest to determine the most appropriate form of control for any intersection, including those having low traffic demands.

A review of the operation of four-legged and T intersections leads to the expectation that these operations would differ considerably. Including diverge conflicts, a T intersection has 9 potential conflict points, while a four-legged intersection has 32. This would seem to justify a preference for the use of two T intersections instead of one four-legged intersection wherever feasible. However, there is an assumption inherent in the foregoing that all of the potential conflict points have equal probabilities of producing accidents under similar traffic loads, regardless of intersection type. This assumption should be evaluated, since the impression given that T intersections operate more safely than four-legged intersections may not be supported in all circumstances.

In particular, if a T intersection is defined as consisting of a street or road forming the top of the T and another forming the stem of the T, the following hypothesis may be stated:

> Drivers typically perceive the top of an uncontrolled T intersection as a through road, giving traffic thereon right-of-way over traffic on the stem of the T regardless of the direction of the traffic on the top of the T.

The Iowa Code definition of a through highway does not support this hypothetical perception, defining a through highway at an intersection as one having a classification as a primary road (17) or as one given preference by the presence of a STOP sign, police officer, or traffic control signal requiring traffic on the intersecting roadway to come to a stop (18). The Iowa Code (19) and the Uniform Vehicle Code (28) both indicate that, if vehicles on intersecting roadways are travelling so as to arrive at nearly the same time at an uncontrolled intersection, the vehicle on the right shall have the right-of-way. None of these references conditions this assignment of right-of-way on the basis of intersection type. Thus, at an uncontrolled T intersection, two vehicles may well arrive at nearly the same time with the driver of a vehicle on the stem of the T having the right-of-way over a vehicle to his left on the top of the T. This is clearly contrary to the driver perception hypothesized above.

It is interesting, then, that the 1983 Iowa Driver's Manual (20) may actually be reinforcing the hypothetical perception of the top of the T as a through road. The only sketch of a T intersection right-of-way situation presented in this reference depicts a vehicle approaching on the top of the T from the left of a vehicle approaching on the stem, yet having the right-of-way because it is an emergency vehicle. It is unlikely that most persons reviewing this reference study it in sufficient depth to make the distinction between the situation depicted and the one in which an ordinary passenger vehicle replaces the emergency vehicle, giving the right-of-way to the vehicle on the stem of the T.

Because a review of the conflict points at T and four-legged intersections gives the impression that T intersections should operate more safely, while it is possible that drivers' perceptions of right-of-way assignment give a contrary indication, it would be useful to generate some facts about pertinent intersection accident data. The following hypothesis may be stated with regard to intersection accident rates:

> The overall accident rate at uncontrolled T intersections is higher than that for uncontrolled four-legged intersections.

With regard to T intersection accident types, the following may be stated:

> There is an unreasonably high proportion of accidents involving stem traffic and vehicles to their left in the population of accidents at uncontrolled T intersections.

The truth of either of these hypotheses could increase the potential for tort claims against a public agency for failure to provide some form of traffic control at a T intersection, and any meaningful results will add to the current efforts to determine the circumstances in which STOP and YIELD control are effective, so the questions raised herein are certainly not trivial.

The hypotheses stated thus far indicate a need for answers to the following questions:

1. To what extent, if any, do drivers fail to understand application of the right-of-way rule at uncontrolled T intersections?

2. Do accident statistics indicate a higher accident rate for uncontrolled T intersections than for uncontrolled four-legged intersections?

3. Do accident statistics indicate a disproportionately high number of accidents at T intersections involving a vehicle approaching from the stem of the T and a vehicle to its left?

An attempt will be made herein to provide definitive answers to all of the above questions.

REVIEW OF RELATED LITERATURE

A recent study by Upchurch (36), undertaken to develop improved STOP and YIELD warrants for four-legged intersections, showed current application of STOP and YIELD signs at four-legged intersections to be overly restrictive, resulting in inefficient operation. Study of T intersections was outside the scope of that work. A recent publication of research problem statements by the Transportation Research Board (31) indicates that there is a need to expand the work of Upchurch to include T intersections. The justification is given that ""T" intersections have operating characteristics which are much different from four-legged intersections...."

The question that naturally arises at this point is: "In what ways are T and four-legged intersections different in their operating characteristics?" The answer is not to be found in many of the standard traffic and transportation references. Design guides (1,2,3,14) are generally concerned with geometrics and do not address the question of intersection type. Some traffic control guides (4,8,9,10,24,29) and related research papers (39) also do not address this question, and even the Transportation and Traffic Engineering Handbook (16) sheds no light on it.

Fortunately, enough studies have been conducted to enable classification of the important differences into two major areas. The first of these is safety. The more obvious studies fitting this classification are those on accident rates and potential conflict points. Equally important, however, are the references that demonstrate the existence of a perception on the part of transportation engineering professionals that a safety difference exists between T and four-legged intersections. These references may make a definitive statement about this perception and the reasons for it, or the evidence of it may appear in a subtle, understated fashion. The second area of difference between T and four-legged intersections is, generally, traffic control. This includes differences in selection of control type and differences in how drivers perceive the assignment of right-of-way. The remainder of this chapter will describe some of the literature applicable to these two areas.

T Versus Four-legged Intersections -- Safety

Traffic Control & Roadway Elements (5) is an important 1963 reference with an extensive bibliography of papers and reports published prior to that time. Chapter VII of that reference covers the topic of intersections and includes references to several studies of interest here. The first is to research conducted in the 1930s showing fewer accidents per intersection at T intersections than at four-legged intersections. Specifically, T, Y, or forked intersections were shown to have an accident rate of 0.41 accidents per intersection, while cross intersections were shown to have a rate of 2.50 accidents per intersection. Unfortunately, no account was taken of traffic volumes for the intersections used in this study. However, later works corrected this shortcoming, with a study from the 1950s indicating that, over the range of traffic volumes studied, four-way intersections had about twice as many accidents as three-way.

Two other studies reported in that reference are also of interest. The first, from the late 1950s, did not look at volume accident rates, but instead concentrated on differences in intersection rates by intersection type and subdivision type. The ratio of the number of accidents at four-way intersections to that at three-way intersections was found to be 14 to 1 for limited access subdivisions and 41 to 1 for gridiron subdivisions. The second, from the early 1960s, reported volume-distance rates for accidents in two different types of subdivisions. The rates reported in two gridiron subdivisions were 2.1 and 1.9 accidents per 100,000 vehicle-miles. In a new subdivision with primarily T intersections, the rate reported was 1.1. This study also determined that four-way intersections had from three to 20 times as many accidents as three-way.

A 1976 study by Hanna and others (13) reported on accident rates by intersection type. The overall rate for T intersections for all control types studied was 0.80 accidents per million entering vehicles, while that for four-way intersections was 1.35. Uncontrolled intersections were not considered in this study.

Obviously, some justification exists, in the literature as well as on a more "common sense" basis, for traffic and tranportation engineers to simply accept that T intersections are inherently safer than four-legged intersections. However, questions still arise on this point. In 1983, Rosenbaum (32) reported on prior research findings regarding STOP versus YIELD control. Included in his report was the finding that "Geometry (three-leg and four-leg) does not play a major role in either the safety or operation of low volume intersections." A 1983 paper by Lum and Parker (22) reports that "There is no relationship between the number of approaches on the minor roadway and accident experience for major volume under 1,000 vpd." Since this latter finding is based on a sample of uncontrolled intersections, this implies that uncontrolled T intersections are no safer or more dangerous than uncontrolled four-legged intersections. It should be pointed out that accident rates were not calculated on a volume basis for this sample, and that the sample size was extremely small, including only 33 intersections. Further study is needed, then, before conclusions may be drawn regarding the relative safety of T and four-legged intersections.

Another tool that has been used to study the question of relative safety of T and four-legged intersections is the calculation of accident exposure indices based on the potential conflict points of the traffic vectors for the intersection approaches. In 1954, Grossman (11) presented a paper to the Highway Research Board that based an accident exposure index for four-legged intersections on the 16 vector crossing points. Merge and diverge points were not considered in this analysis. Similar work by Surti (35) in 1965 included merge points as potential conflicts, so 24 potential conflicts were utilized for four-legged intersections. Another paper by Surti (34) in 1969 included accident exposure analyses for both four-legged and T intersections. The number of potential collision points used to calculate the exposure indices for four-legged and T intersections was 24 and 6, respectively.

A paper by Brain (6) in 1966 on design of various high-type T intersections and interchanges views accident exposure at T intersections in light of 9 conflict points. This means crossing, merge, and diverge points were all included in the analysis. Since diverge points present a potential for conflict, it is reasonable to view accident exposure in light of 32 potential conflict points at a four-legged intersection. Figures 1 and 2 show the potential conflict points at four-legged and T intersections, respectively.

To demonstrate that transportation engineering professionals feel that T intersections are inherently safer than four-legged intersections, it is only necessary to look at a few key references. Returning to Traffic Control & Roadway Elements (5), the following quote very explicitly states the interpretation of the findings presented above, as well as others: "In addition, the findings ... tend to show that three-way intersections are inherently safer than four-way. This probably results from fewer points of possible conflict in three-way intersections ...." Recommended Guidelines for Subdivision Streets (15) encourages discontinuities in local street patterns to minimize through traffic movements and to discourage excessive speeds. In addition, "There should be a minimum number of intersections. ... From the

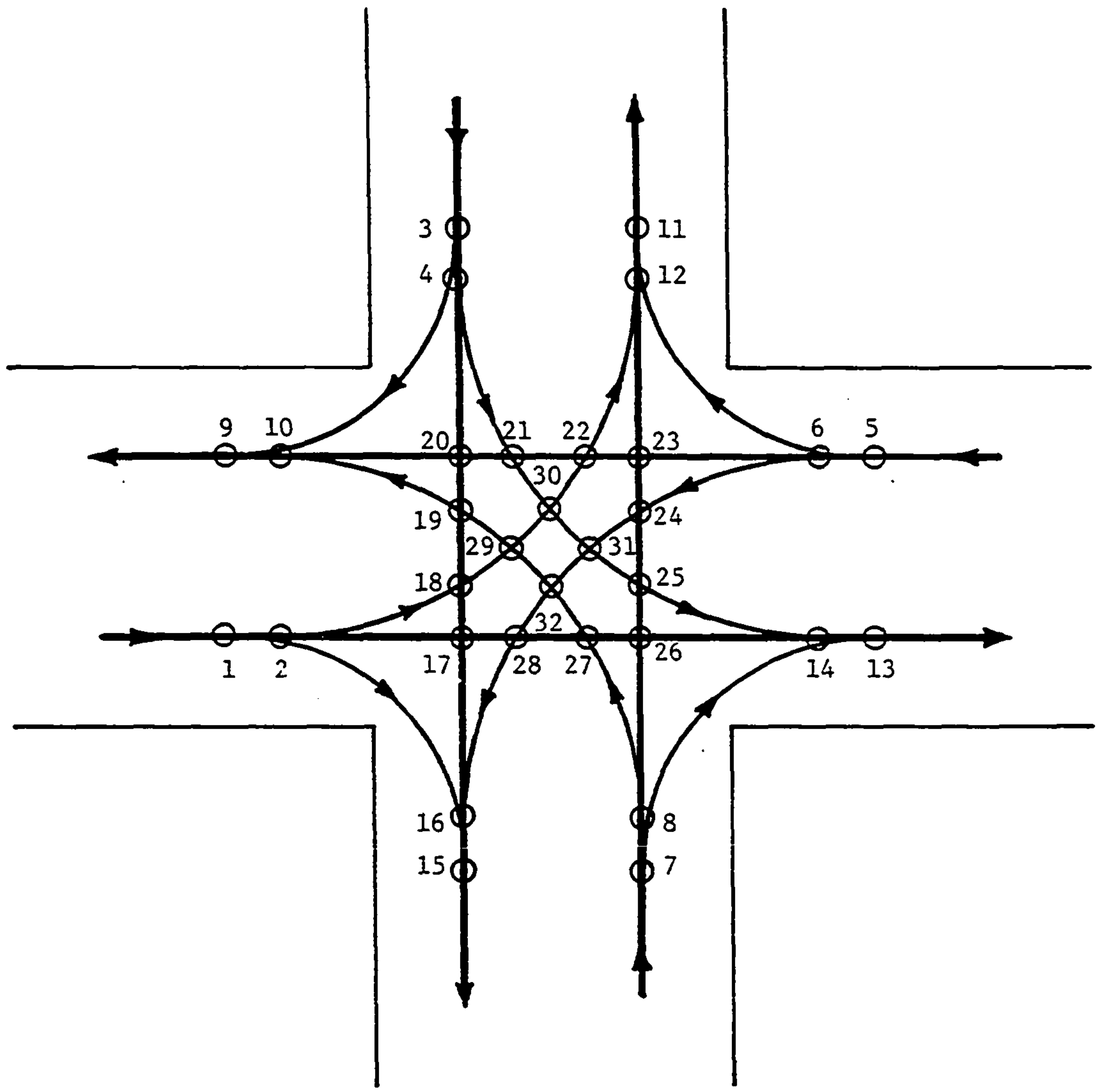


FIGURE 1. Four-legged intersection potential conflicts

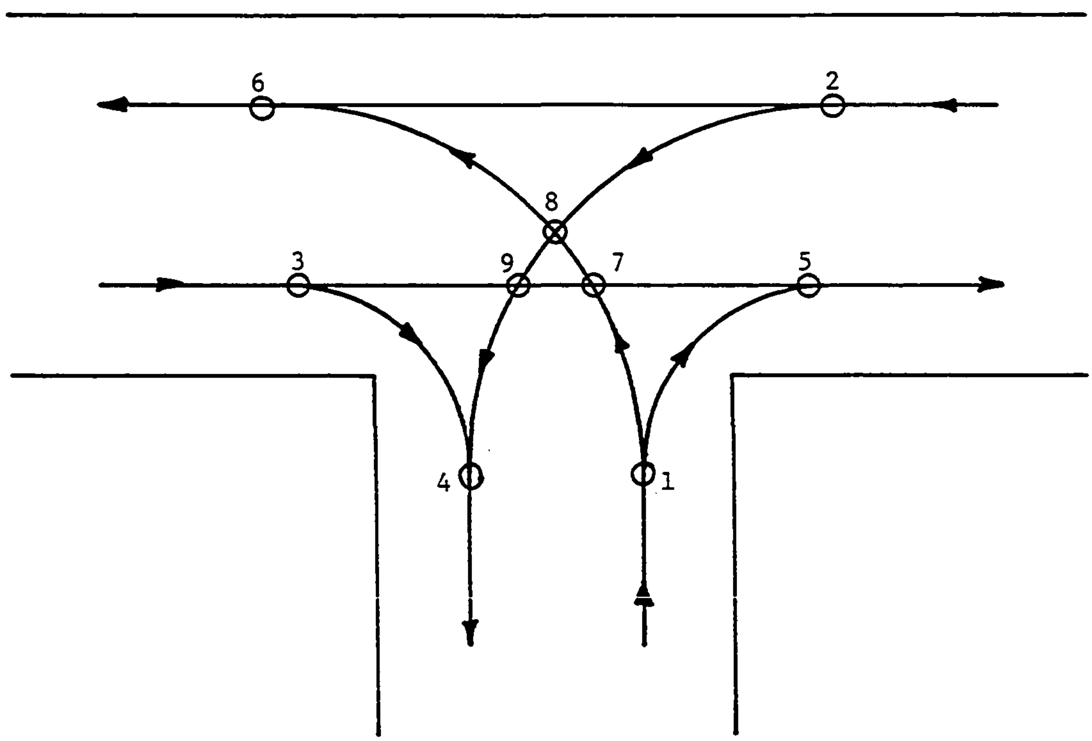


FIGURE 2. T intersection potential conflicts

standpoint of hazard, however, use of two T-type intersections with proper offset is preferable to using one cross-type, within the subdivision." Also, "Several studies of intersection design types have shown T-type intersections to be far safer than cross-type. Extensive use of T intersections in residential subivisions is strongly recommended." Further, in Residential Streets -- Objectives, Principles, & Design Considerations (37), "Whenever possible, residential street layouts should be planned to avoid four-way intersections."

That the foregoing statements are definitive with regard to the perception that T intersections are safer than four-legged intersections can hardly be doubted. A paper by Van Winkle (38) regarding commercial access to highways is somewhat less of a wholehearted endorsement of T intersections, but details several advantages they have over four-legged intersections. Specific examples are provided of the circumstances in which they might prove superior, including channelization and traffic control details necessary for successful operation. A study of YIELD sign usage reported in 1978 (21) detailed the experiences of several cities with YIELD signs, including changes from no control to YIELD and from STOP control to YIELD. In St. Petersburg, Florida, YIELD signs were replaced with STOP signs after a period of 10 or more years due to increasing vehicle speeds. Significantly, this was not done at T intersections, implying a perception of a higher level of safety at the T intersections.

T Versus Four-legged Intersections -- Traffic Control

To set the background for a discussion of the differences that may exist in selection of appropriate traffic control for T intersections and for four-legged intersections, it is useful to review the warrants for STOP and YIELD signs from the Manual on Uniform Traffic Control Devices (24) that might be applied to T intersections particularly due to their unique operating characteristics.

For the installation of STOP signs, warrants 1 and 2 are of interest:

1. Intersection of a less important road with a main road where application of the normal right-of-way rule is unduly hazardous.
2. Street entering a through highway or street.

Warrant 1 is especially pertinent, since if a perception problem does in fact exist with regard to right-of-way assignment at uncontrolled T intersections, application of the normal right-of-way rule could indeed be unduly hazardous. Warrant 2 is of interest primarily due to the potential for drivers to view the street forming the top of a T intersection as a through street, though it is not so defined in most applicable laws.

The above warrants for STOP signs are also applicable, in some instances, to the installation of YIELD signs. This is made clear by the statement, following the STOP sign warrants, that "Prior to the application of these warrants, consideration should be given to less restrictive measures, such as the YIELD sign (2B-7) where a full stop is not necessary at all times." Specific warrants for YIELD sign control that are of interest here include numbers 1 and 5, as follows:

1. On a minor road at the entrance to an intersection where it is necessary to assign right-of-way to the major road, but where a stop is not necessary at all times, and where the safe approach speed on the minor road exceeds 10 miles per hour.

5. At any intersection where a special problem exists and where an engineering study indicates the problem to be susceptible to correction by use of the YIELD sign.

The existence of confusion in the perception of right-of-way could justify application of warrant 5 for YIELD control at a T intersection. Warrant 1 would also apply in cases where the major flow of traffic is across the top of the T.

In a 1983 paper, Smith (33) presented materials from a traffic control handbook prepared for use on low volume roads in Kansas. The material indicates that, on the basis of positive guidance principles, a T or Y intersection is classed as an "inconsistency." Further, for all low volume rural road types, such intersections "should" be signed, unless adequate sight distance is provided. Tables are provided to define "adequate" sight distance. The recommended signing ranges from installation of T intersection warning signs to STOP control, depending on the sight distance available.

In yet another handbook, written by Bunte (7) for second and third class cities in Missouri, there is further evidence of reluctance to leave T intersections uncontrolled. In a section on "other" uses for STOP signs, the author states, with regard to the T intersection of two "major roads": "At a minimum, the road entering on the leg of the "T" should be stopped." Unfortunately, the term "major road" is not defined in this reference.

There are some interesting observations that can be made at this point. The city of St. Petersburg chose to leave YIELD control in place at T intersections while converting from YIELD to STOP control at four-legged intersections. This would seem to indicate a perception of some advantage in the positive assignment of right-of-way by using YIELD signs at T intersections, while indicating that perhaps the positive control generally attributed to the use of STOP signs is not needed as much as at four-legged intersections. Evidence from Kansas and Missouri indicates a reluctance to leave T intersections uncontrolled, but indicates a need for STOP signs only on major roads or under the worst conditions of available sight distance. It is apparent that T intersections are considered by some engineers to be safer than four-legged intersections. It is also apparent that these same engineers are reluctant to leave T intersections uncontrolled. Perhaps they recognize a difference between drivers' perception and the law with regard to assignment of right-of-way at uncontrolled T intersections.

Clearly, it would be inefficient at best to install STOP signs at all low volume intersections. A study by Hall and others (12) examined the costs associated with the use of STOP, YIELD, and no control at low volume intersections to determine the most efficient signing policy. Among their conclusions is the following: "... yield signs are the most desirable form of control at low-volume intersections. Yield signs provide the optimal trade-off between the safety factor and the variables of travel time, gasoline consumption, and exhaust emissions." However, at traffic volumes of less than about 200 vehicles per day, no control is shown to be economically preferable to YIELD control when installation and maintenance costs are included. Differences in operating characteristics of T and four-legged intersections are not considered in this study, but the importance of determining the most efficient control policy is quite clear from the results presented.

In comparing traffic laws in the 50 states with certain sections of the Uniform Vehicle Code (28), the 1972 edition of Traffic Laws Annotated (25) identified the State of Arizona as one having a special right-of-way rule for T intersections. A review of the 1979 edition of Traffic Laws Annotated (26) revealed that Connecticut, Georgia, and Texas have also passed laws providing such special right-of-way rules. The 1983 Traffic Laws Annotated Annual Cumulative Supplement (27) further identified California, Illinois, Maryland, and Nevada as states having passed similar laws.

A review of these special rules reveals that they all require the driver of the vehicle travelling on the roadway terminating at the intersection to yield, stop, or otherwise relinquish the right-of-way to the driver of any vehicle on the other roadway travelling so as to enter the intersection at about the same time, regardless of the direction of travel of the second vehicle. Certainly, the legislatures in these eight states feel that the normal right-of-way rule may be unduly confusing to drivers at T intersections.

When a potential exists for drivers to become confused, engineers frequently turn to positive guidance principles in their search for solutions to the anticipated or actual problems resulting. It would be worthwhile, then to explore briefly just what positive guidance is. According to A Users' Guide to Positive Guidance (30), positive guidance principles are based on a combination of human factors engineering and traffic engineering. The system of positive guidance "... centers around determining what information the driver needs and how best to transmit it." With regard to driver expectancy: "Driver expectancy ... is primarily a function of the driver's experience. If an expectancy is met, driver performance tends to be error free. When an expectancy is violated, longer response time and incorrect behavior usually result." Further, "A hazard is any object, condition, or situation which, when the driver fails to respond successfully, tends to produce a catastrophic system failure." And "Condition hazards are highway, vehicle, driver, and environment types." It should be noted that a catastrophic system failure is, or at least can be, an accident.

To reduce the foregoing to simple terms, if the driver encounters an unexpected condition in his or her travels, an accident could result if he is not provided with ample and timely warning. In labeling a T or Y intersection an "inconsistency", Smith (33) has determined that such an intersection constitutes a condition hazard, and, if left unsigned, could result in a catastrophic system failure or, simply, an accident. The question of why a T or Y intersection is an inconsistency is not addressed in the above reference. Thus, it may be that in low volume situations, drivers may simply not expect to encounter T or Y intersections. The possibility of confusion in the perception of right-of-way at uncontrolled T intersections, however, still remains.

In an attempt to learn whether such confusion has been documented through research, telephone contacts were made with persons in the eight states having special T intersection right-of-way rules. The individuals contacted were determined to be in a position in their state's government that would assure their familiarity with changes in traffic laws and with any related studies. No studies were identified that could have precipitated these legislative actions. There is, therefore, a noticeable void in the literature with regard to the documentation of any confusion in the perception of right-of-way at T intersections. The next chapter in this work will attempt to at least partially remedy that situation.

QUESTIONNAIRE SURVEY OF IOWA DRIVERS

The most direct way to determine if confusion in the perception of right-of-way exists for a particular driving situation is to ask a driver. In order to increase the statistical significance of the result of this questioning, several drivers should be asked. In the study documented herein, one thousand drivers were asked. Further, several questions were asked of each driver so that the responses could be interpreted more precisely. Particularly, questionnaires were developed and distributed to licensed drivers, and the returns were evaluated in light of the research objectives. For reference, Appendix A contains a reproduction of the questionnaire.

Questionnaire Development

If there is confusion at a T intersection with regard to the assignment of right-of-way, the situation most likely to give rise to confusion is that in which the vehicle arriving on the stem of the T is to the right of the vehicle arriving on the top of the T. Figure 3 shows such a situation.

The use of words to describe this situation to a driver could result in confusion and a lack of interest in completing the questionnaire; therefore, a sketch was used to help convey questions to those drivers attempting to complete questionnaires. The sketch allowed a very simple question to be asked in order to determine whether confusion does exist with regard to the situation depicted. The question used was "Which vehicle has the right-of-way?"

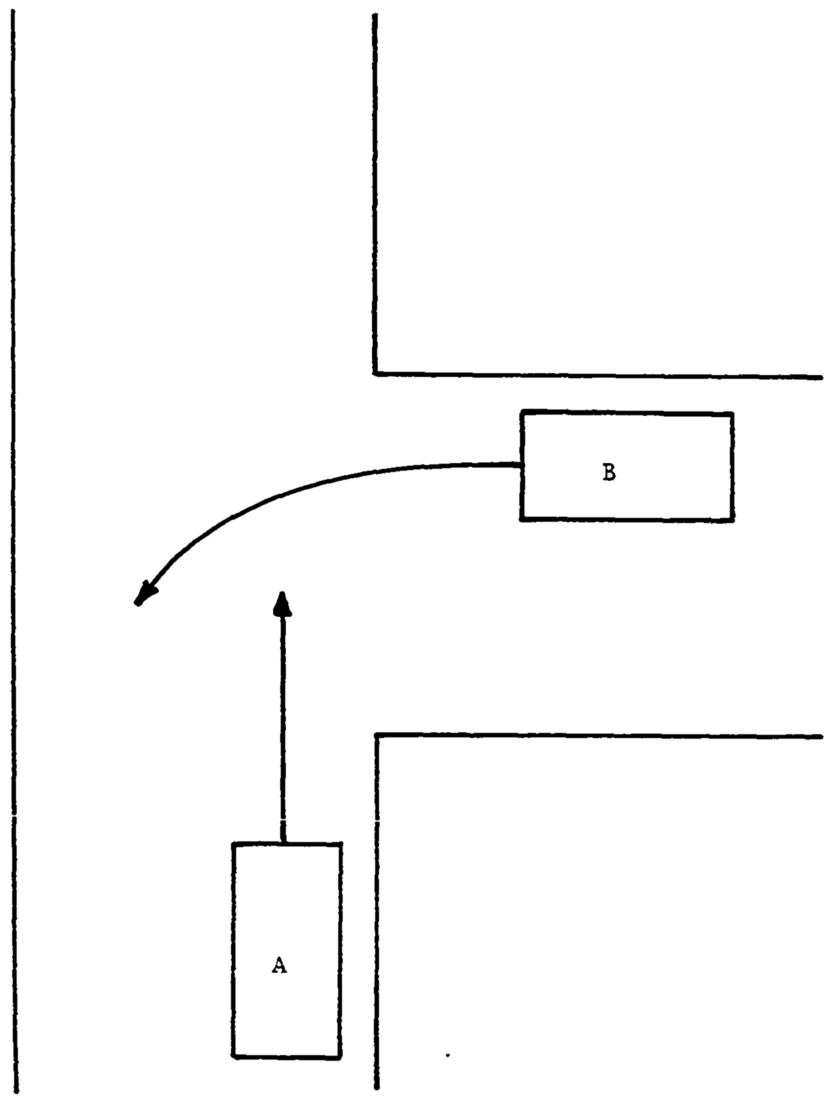


FIGURE 3. T intersection, stem vehicle on right

Because it was anticipated that drivers might be sufficiently acquainted with applicable traffic laws to correctly answer that question, it was accompanied by two multiple choice questions. These questions were essentially the same, except that each was related to a different one of the vehicles shown in the sketch. Specifically, drivers were asked to choose the appropriate driving action for each of the vehicles indicated. A driver answering the first question correctly, but answering either of the multiple choice questions incorrectly, could be considered as providing some limited evidence of confusion in the perception of right-of-way assignment. The same four driving choices were given for each vehicle. The first choice was to yield right-of-way, stopping if necessary. The remaining choices given were progressively less restrictive, with the second being to slow down and proceed with caution, the third choice being to proceed without slowing, and the last choice being to assume the right-of-way and proceed quickly through the intersection before the other vehicle. A blank space was also provided for "other" responses.

In Figure 3, vehicle B has the right-of-way. Any driver incorrectly selecting vehicle A as having the right-of-way was considered to be of some interest, purely on the basis of the confusion involved in such a selection. However, certain drivers provide no evidence either proving or disproving the existence of confusion with regard to the right-of-way at uncontrolled T intersections. Specifically, only those drivers that can correctly identify who has the right-of-way in other driving situations while being unable correctly to identify the vehicle having the right-of-way in driving situations similar to that depicted in Figure 3 provide any proof of confusion in the perception of right-of-way at uncontrolled T intersections as hypothesized in this study. Thus, drivers unable correctly to identify the vehicle having the right-of-way in driving situations other than that depicted in Figure 3 must be, in effect, "filtered out" by the use of questions related to additional driving situations coupled with appropriate analyses. Discussion of these additional driving situations follows.

The first such situation considered was that in which a driver approaching a T intersection on the stem must yield to a driver approaching on the top of the T from his right. Figure 4 shows this situation, in which vehicle A clearly has the right-of-way. The same three questions associated with the first sketch accompanied the sketches of this and all subsequent driving situations on the questionnaire.

It was also necessary to consider another factor that could cause some confusion at T intersections. Vehicle B, the "stem" vehicle in Figures 3 and 4, is required to turn in order to negotiate the intersection. A left turn was indicated on all the sketches used on the questionnaire so as to provide uniformity in the driving movements represented. Further, it was felt that the crossing conflict resulting from this left turn in Figures 3 and 5, the driving situations of prime

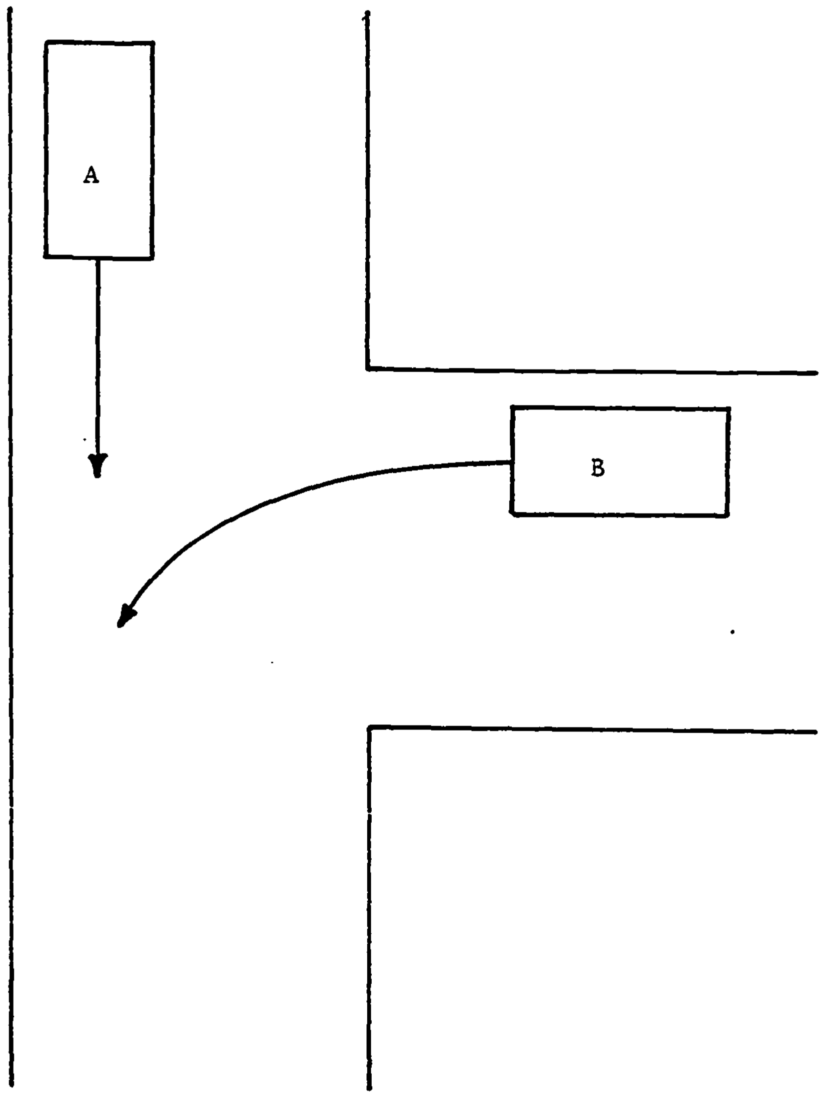


FIGURE 4. T intersection, stem vehicle on left

interest in this study, would be easier for most drivers to interpret than the merging conflict that would result had a right turn been indicated. Even if this proved true, it was still possible that some drivers might incorrectly select a vehicle as having the right-of-way on the basis of requiring the turning vehicle to yield. It seemed appropriate to control for this turning vehicle effect and this was effectively accomplished by the aforementioned use of left turns for one vehicle in all the driving situations presented, both for T and four-legged intersections.

The hypothesis of confusion in right-of-way perception at uncontrolled T intersections must be compared to the situation that exists at uncontrolled four-legged intersections. Any depiction of a four-legged intersection with two vehicles approaching at right angles would be appropriate for this, but the use of two specific sketches depicting driving situations corresponding to each of the T intersection situations was considered superior because they provided the means for controlling the turning vehicle effect in the study. Two such sketches were therefore included in the questionnaire.

The first control sketch, shown in Figure 5, depicted a situation in which the turning vehicle has the right-of-way. This sketch corresponds to the T intersection situation depicted in Figure 3, in which the "stem" vehicle has the right-of-way. Respondents interpreting the four-legged stuation correctly and the T situation incorrectly in these two sketches were of particular interest to this study.

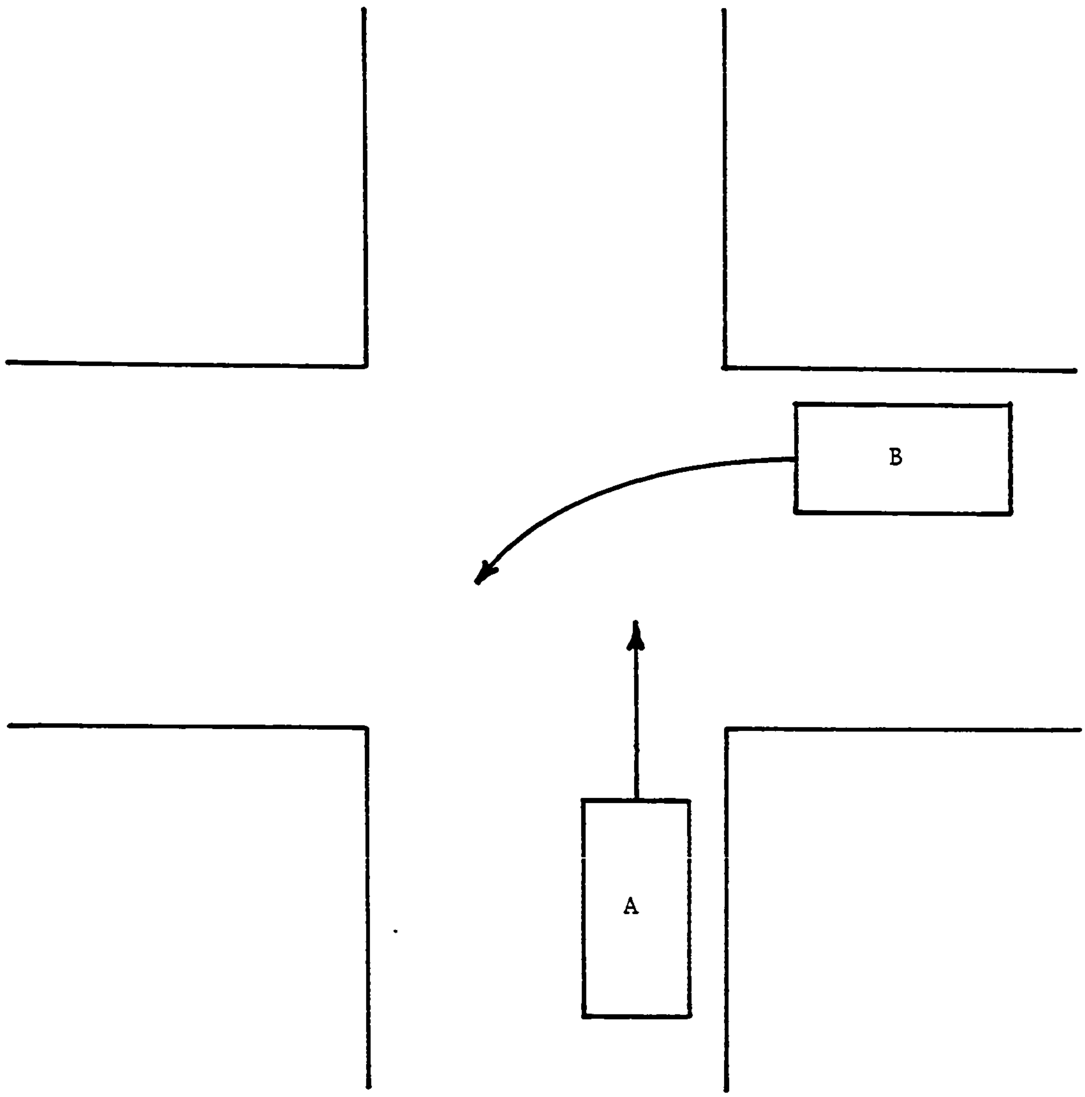


FIGURE 5. Four-legged intersection, turning vehicle on right

The second four-legged situation used, shown in Figure 6, depicted a situation in which the turning vehicle must yield to the vehicle travelling straight through the intersection. This corresponds to the T intersection situation depicted in Figure 4, in which the "stem" vehicle must yield the right-of-way. It was not anticipated that many drivers would interpret either of these two situations incorrectly.

Having selected the sketches to use for conveying appropriate questions to licensed drivers, an arrangement of the sketches and accompanying questions was selected. With three questions for each driving situation, it was decided to use each sketch only once, clustering the questions with the sketches. This was expected to simplify the task of answer selection; however, the arrangement of the sketches presented a different problem. If the sketches were ordered in a systematic pattern, they might suggest the correct answers to respondents, resulting in a reduction of significance in whatever findings came from the analysis of returns. It was decided to randomize both the order of appearance of the sketches and the orientation of the intersections in the sketches, starting from an arbitrary order and set of orientations. Figure 7 shows the resulting order and orientations.

In developing the questionnaire, consideration was also given to the need for socio-economic information about the respondents. Such information could help to determine if drivers sharing confusion in the perception of right-of-way at uncontrolled T intersections also shared other characteristics. This in turn could provide insight regarding the

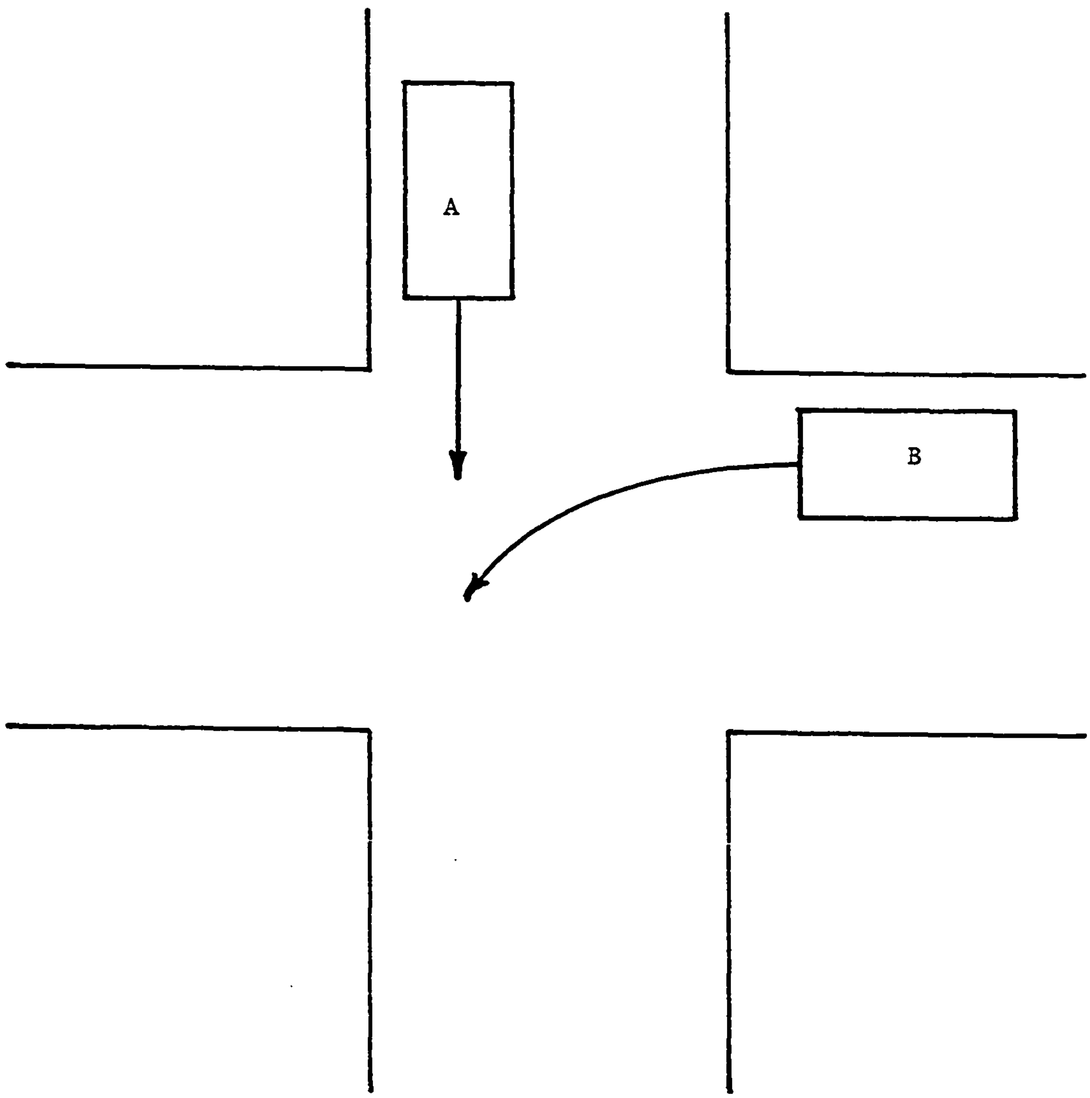


FIGURE 6. Four-legged intersection, turning vehicle on left

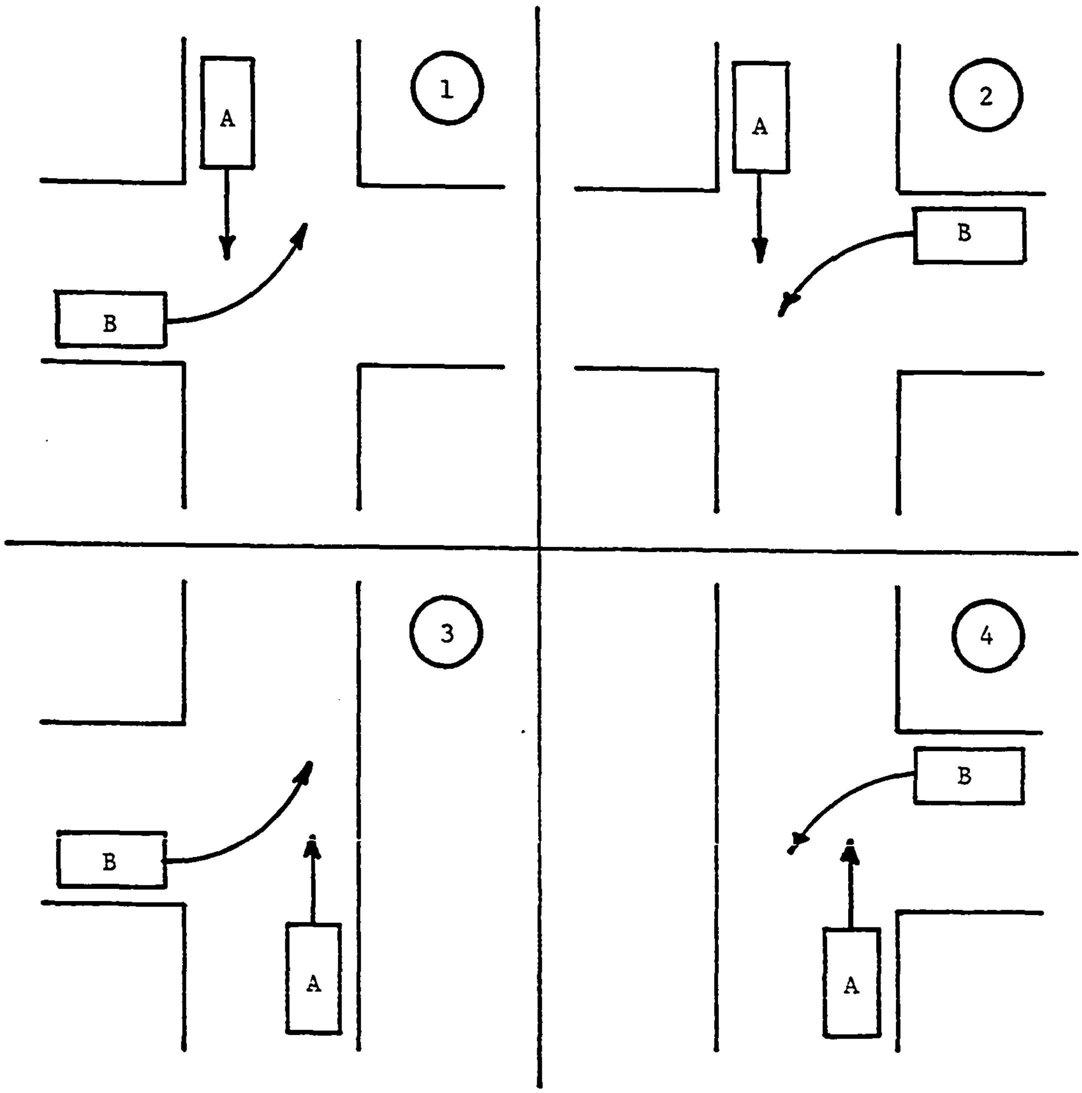


FIGURE 7. Four intersections with randomized orientations

reasons for such confusion, or could assist in development of strategies for its elimination, such as public education programs or public service announcements in the electronic media.

Care was taken to avoid questions about the respondents that might have been interpreted as being either inflammatory or too personal. For example, no information was requested on the sex of the respondent, due to the current mood in our society that sex really should not matter. It was expected that such omissions would improve the percentage of questionnaires returned. Further, the size of the return was of greater importance to the objectives of the study than the inclusion of such questions.

However, some personal information was felt to be needed, so questions were included on age, residential area type, education, and family income. Another item of information was obtained by hand-lettering a site code on each questionnaire distributed to identify the city where it was distributed. The topic of family income was expected to bother some drivers and perhaps to reduce the size of the return. This reduction was expected to be offset at least partially by measures taken to assure the confidentiality of the returns. Instructions were provided to place no identifying marks of any kind anywhere on the questionnaire.

In addition to social and economic information about drivers, it was anticipated that the presence or absence of confusion in the perception of right-of-way may somehow be related to driving experience.

Age has already been mentioned as being included, and is obviously related to experience. Other experience-related variables selected as being of interest to this study included annual driving mileage, whether driver education was taken, time since driver education, and age at which the driver's license was first received. More sensitive information was also requested, including whether the driver's license had ever been revoked or suspended, and whether the driver had been involved in a motor vehicle accident within the past two years.

Uncontrolled intersections are likely to be found on low volume roads, and a commonly occurring low volume road situation, at least in Iowa, is the gravel surfaced road. In order to establish a common and familiar basis for consideration of the questions on the questionnaire in the minds of the respondents, the descriptive material written to accompany the sketches of the four driving situations included in the questionnaire indicated that the roads involved were gravel roads. A separate question asked what percent of the respondent's driving in the past year had been on gravel roads.

Having selected the questions and descriptive material for inclusion in the questionnare, it was then necessary to design its physical layout. A primary consideration in achieving a high percentage of returns was to avoid intimidating the respondents. A single-sheet layout was considered to be highly desirable for this purpose and was also considered to have advantages in mailing considerations. It could be pre-folded, stamped, and addressed so that the respondent need only staple the sheet and drop it in a mailbox. An 8.5 by 11 inch sheet would not accommodate all the questions selected for use and still have sufficient blank area remaining for a suitable "outside" surface for mailing. An 8.5 by 14 inch sheet was therefore selected.

In order to avoid confusing the respondents, questions were clustered on the questionnaire according to content. It was necessary to use one entire side of the sheet for questions related to the intersection driving situations. On the other side, care was taken to use no more than half of the surface for the questions related to the driver so that they could be folded "inside" for mailing. A mailing address and stapling information were strategically placed on the other half, and the forms were then pre-folded and stamped in preparation for distribution.

It should be noted here that another document was required for distribution with some of the questionnaires. In order to obtain the approval of the Iowa State University Committee on the Use of Human Subjects in Research, necessary for distribution of the questionnaire, it was necessary to provide a document to all potential respondents under 18 years of age explaining their rights with regard to the research being conducted and the benefits they could expect to receive as a result of their participation. A copy of this document is included in Appendix B.

Survey Procedure

Selection of a questionnaire distribution procedure was not a difficult task. A random mailing of questionnaires was not seriously considered, as such a mailing would not be certain to reach only licensed drivers. Further, it would not necessarily identify individuals with some inclination to volunteer to respond to the questionnaire. The percentage of returns from such a mailing was not expected to be sufficiently high to justify that method of distribution. Because a printed questionnaire was considered to be desirable for conveying the questions of interest, a telephone interview was also out of the question.

The procedure chosen was the distribution of questionnaires in enclosed shopping malls. This procedure offered face-to-face contact between this investigator and the potential respondents. Thus, any question about the age of a respondent, or whether the respondent was indeed a licensed driver, could easily be asked at the distribution site. Further, shopping malls offered an environmentally sheltered area within which to make this face-to-face contact. More importantly, they offered an audience, a collection of persons generally of driving age from which to solicit volunteers for completing questionnaires.

Because the nature of the terrain varies across the State of Iowa, low-volume rural roads and the driving conditions encountered thereon may be expected to vary. It was, therefore, considered to be of some importance to select questionnaire distribution sites with a considerable amount of geographic dispersion across the State. This was to assure responses from a sample of drivers with a wide variety of driving experience with regard to the driving conditions generally encountered in Iowa. In Figure 8, it can be seen that some geographic dispersion was attained in the location of questionnaire distribution sites.

Another important consideration to this investigator was to distribute questionnaires in most of the larger metropolitan areas in Iowa. This was to assure a sample with a diversity of urban driving experience, as well as, hopefully, to assure an ample supply of volunteers for completing the questionnaires. Some success in this was assured, because enclosed shopping malls are generally only found in the larger urban areas. Table 1 provides a listing of the 20 largest cities in Iowa, and those used as questionnaire distribution sites are noted. Again, some degree of success was attained in this aspect of questionnaire distribution site selection.

A parameter of prime interest in this study was the percentage of drivers failing properly to identify the vehicle having the right-of-way in driving situations similar to that depicted in Figure 3. It was decided that an estimate of this value within five percent would be adequate for this study. Further, it was decided that the confidence level for this value should be at least 95 percent. Knowing that the sample size should be well over 30, the standard normal distribution could be used to estimate the required sample size to satisfy the

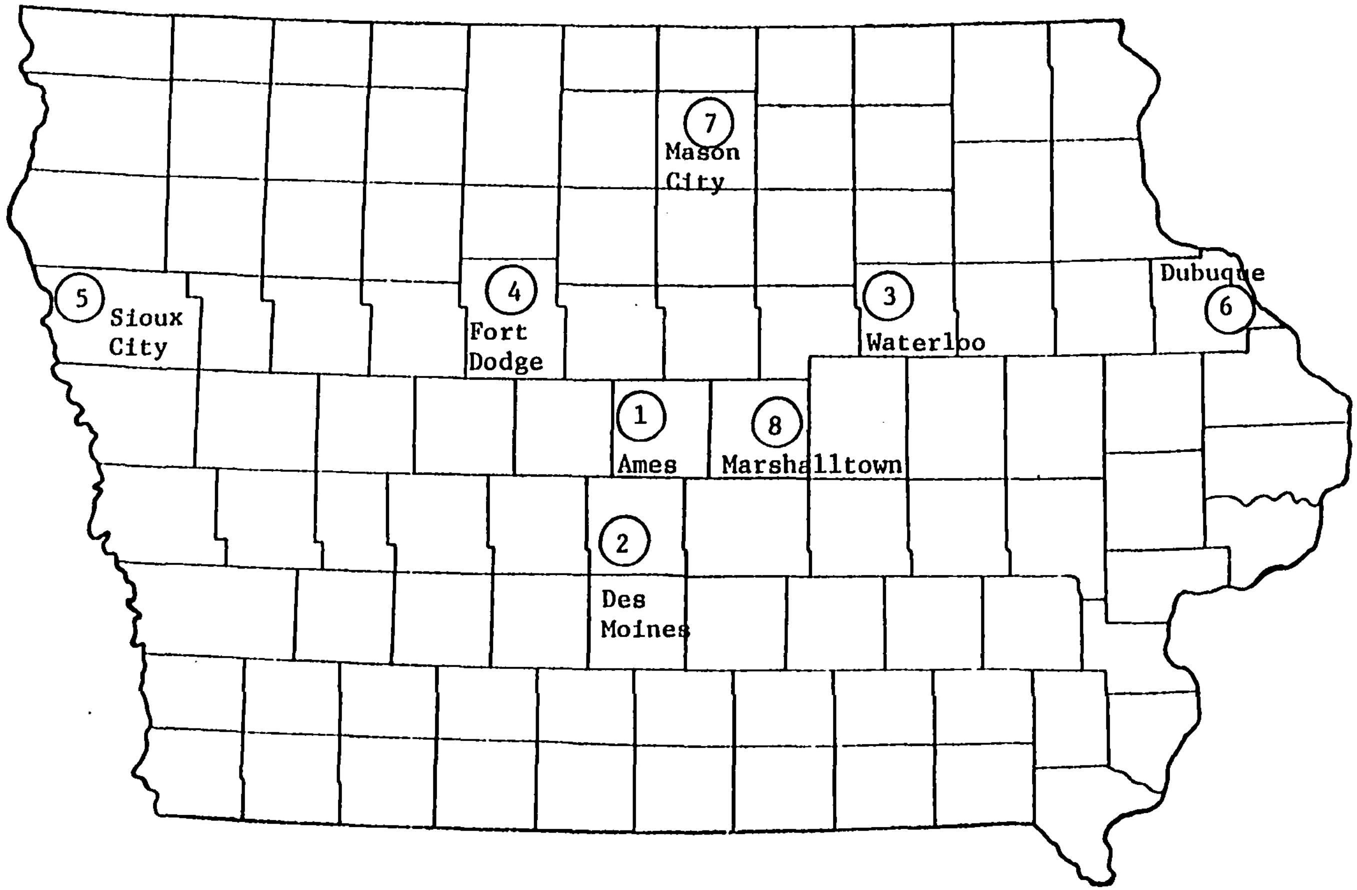


Figure 8. Questionnaire distribution sites

TABLE 1. Iowa cities by population

Rank	City	Population (approx.)
1	Des Moines[a]	191,000
2	Cedar Rapids	110,000
3	Davenport	103,000
4	Sioux City[a]	82,000
5	Waterloo[a]	76,000
6	Dubuque[a]	62,000
7	Council Bluffs	56,000
8	Iowa City	51,000
9	Ames[a]	46,000
10	Cedar Falls	36,000
11	Clinton	33,000
12	Mason City[a]	30,000
13	Burlington	30,000
14	Fort Dodge[a]	29,000
15	Bettendorf	27,000
16	Ottumwa	27,000
17	Marshalltown[a]	27,000
18	Muscatine	23,000
19	West Des Moines	22,000
20	Marion	19,000

[a]Indicates Questionnaire Distribution Site.

foregoing requirements for the proportion of incorrect responses in the returns, which is a binomial parameter. Because nothing was known about the value of this parameter in advance, sample size calculations were based on an assumed value of 0.5 for the proportion of incorrect responses in the returns, meaning the sample size calculated would give a confidence level of at least 95 percent for the given error size. The sample size calculated for the above requirements was 384. If a return of 40 percent of the questionnaires distributed could be expected, this meant 1000 questionnaires must be distributed. In Table 2, the questionnaire distribution sites are listed along with the number of questionnaires distributed at each and the number of returns. As planned, 1000 questionnaires were distributed, and the return, 529 questionnaires, was far better than had been expected.

TABLE 2. Questionnaires distributed and returned by site

Site	Site Code	Number Distributed	Number Returned[a]
Des Moines	D	250	141[b]
Sioux City	S	190	98
Waterloo	W	100	56
Dubuque	Q	100	48
Ames	A	100	50
Mason City	M	90	53
Fort Dodge	F	100	51
Marshalltown	T	70	32
TOTALS		1,000	529

[a]Not including three questionnaires returned after analysis was essentially completed.

[b]Including one invalid response not used in analysis.

So far, it has been indicated that geographical dispersion, city population, and sample size were all considered in questionnaire distribution site selection. Another factor was also a major determinant of the sites selected. This factor was management approval. It was quickly learned that many shopping mall managers have policies strictly forbidding the distribution of any printed materials on mall property. Further, the process for obtaining permission to distribute questionnaires within a shopping mall varied considerably. At one extreme, all that was needed was a single telephone call. At the other extreme, the initial telephone contact was followed by a letter requesting permission to distribute questionnaires or completion of a standard request form required by the mall manager, following which an agreement to abide by management rules and policies was signed. Appendix C has copies of printed materials used or obtained in the process of obtaining permission to use shopping mall space for questionnaire distribution.

In order to induce shoppers to spend some of their time doing something other than shopping, a visual device of some kind was needed. In addition to attracting the attention of shoppers, such a visual device should identify the type of research effort, the specific qualifications needed for volunteers to fill out the questionnaires, the person performing the research, and the institutional affiliation of that person. A poster was designed and constructed fulfilling these requirements, as well as meeting requirements imposed by others. The shopping mall managers imposed a size restriction on the poster. In order to fit into poster stands available and required for use at some of the shopping malls, the poster was required to measure 22 by 28 inches. Another restriction on the poster was that it was subjected to the same approval process within Iowa State University as the printed materials being distributed. A reduced photocopy of the poster used is displayed in Appendix D.

The distribution of the questionnaires required adherence to a prescribed format. Shopping mall managers were unanimous in requiring that no active soliciting of mall patrons be performed. This investigator was, therefore, required to smile at and make eye contact with as many persons as possible while seated at a table in a shopping mall. If this resulted in a polite verbal exchange of greetings, this exchange was followed by a brief explanation of the research project. Care was taken to avoid giving too much explanation of the project, lest the explanation unduly influence the answers given on the questionnaires. At this point in the conversation, the mall patron, if a licensed driver, was offered a questionnaire to complete. It was pointed out that the questionnaire could be taken along and filled out later, though pencils were provided for those who wished to fill out the questionnaire immediately. Volunteers were reminded that the questionnaire should be refolded and stapled prior to being mailed, and that their mailing of the questionnaires assured the confidentiality of their responses. No questionnaires were accepted directly from a respondent after being filled out.

It was the opinion of this investigator that different socio-economic groups within the Iowa population might possess differing shopping habits with respect to time of day and day of the week. To avoid having some groups over-represented in the sample while other groups were under-represented, distribution dates were selected so as to scatter the dates over the different days of the week, particularly with regard to weekday versus weekend dates. Distribution times were selected so as to obtain a sample of both daytime and nighttime shoppers.

Efforts to distribute the questionnaires in a manner meeting the various objectives and constraints mentioned in the foregoing were generally successful. In fact, the few problems that were not well handled were all due to the use of only a single person for the task of questionnaire distribution. Distribution of the required number of questionnaires was so time-consuming that consideration of time off for meals and bathroom breaks was essential. The question of what to do with materials during those breaks was also not easily handled. Further, one person could only face half of the foot traffic in a shopping mall, reducing potential for obtaining volunteers. Generally, any future effort of a similar nature to this one should be accomplished with a questionnaire distribution crew of at least two persons.

Analysis

Respondent profiles

As a first consideration in the analysis of the data from the questionnaire returns, it was deemed reasonable to describe the sample of licensed drivers represented therein. Beginning with socio-economic variables, the mean age of the respondents was 38.4, with a range of 16 to 80 years of age. Figure 9 presents a histogram of the ages represented in the sample. Young adults predominate, with persons in their 20s being most frequently counted among the respondents.

Figure 10 reveals that the majority of respondents were from residential areas they considered to be urban in character. With over one-third of the respondents being from one of the three lesser-represented types of residential areas, suburbs, small towns, and rural areas, these were also well represented.

The family incomes of the respondents were primarily between 10 and 40 thousand dollars annually. A review of the information presented in Figure 11 reveals that no income class is in short supply in the sample, with the three least-represented classes each containing about 10 percent of the total sample.

The education levels of respondents is quite another matter. No driver responding to the questionnaire claimed to have less than an eighth grade education, as seen in Figure 12, and fewer than five percent of the respondents indicated that they had less than a complete high school education. Another education category with little

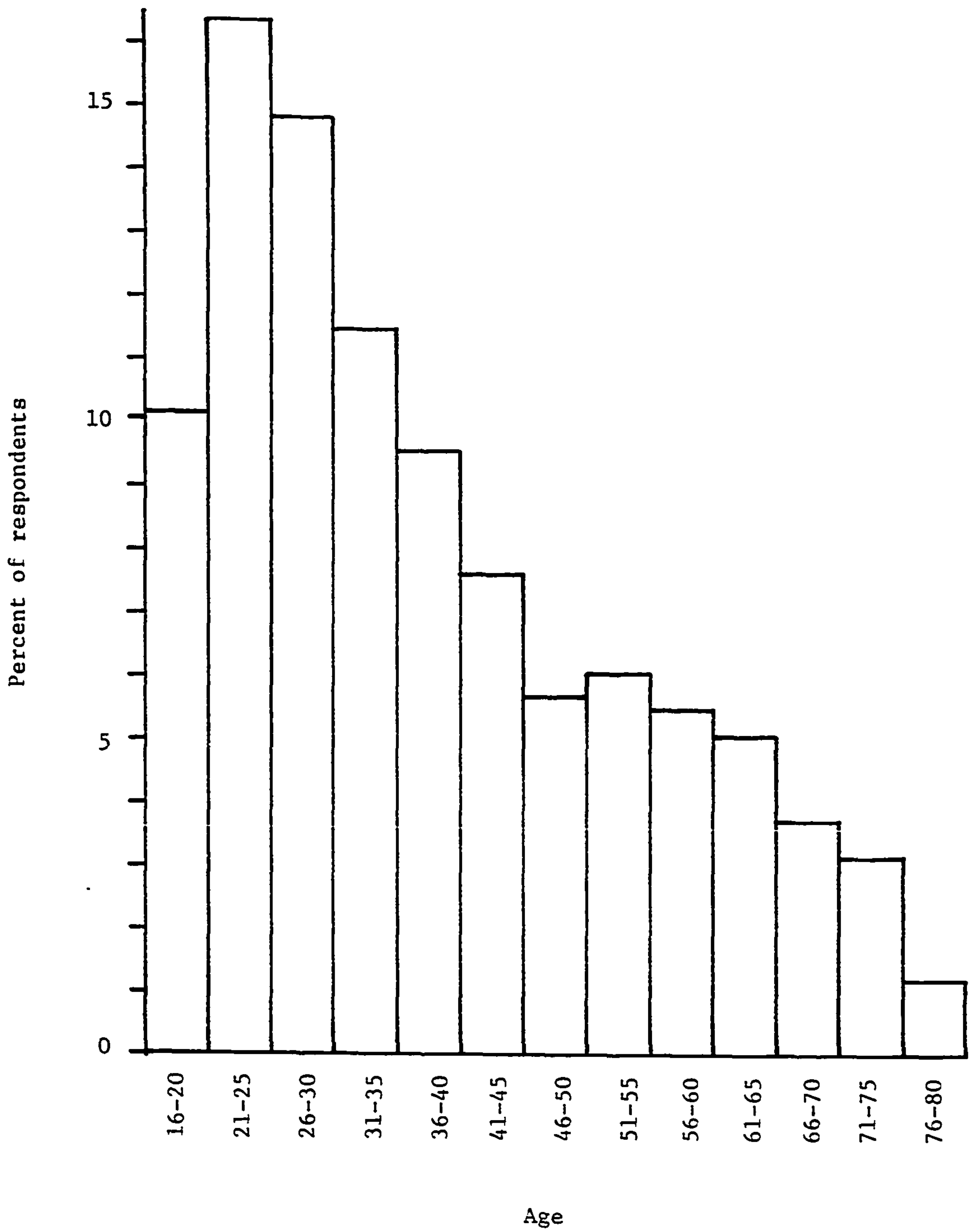
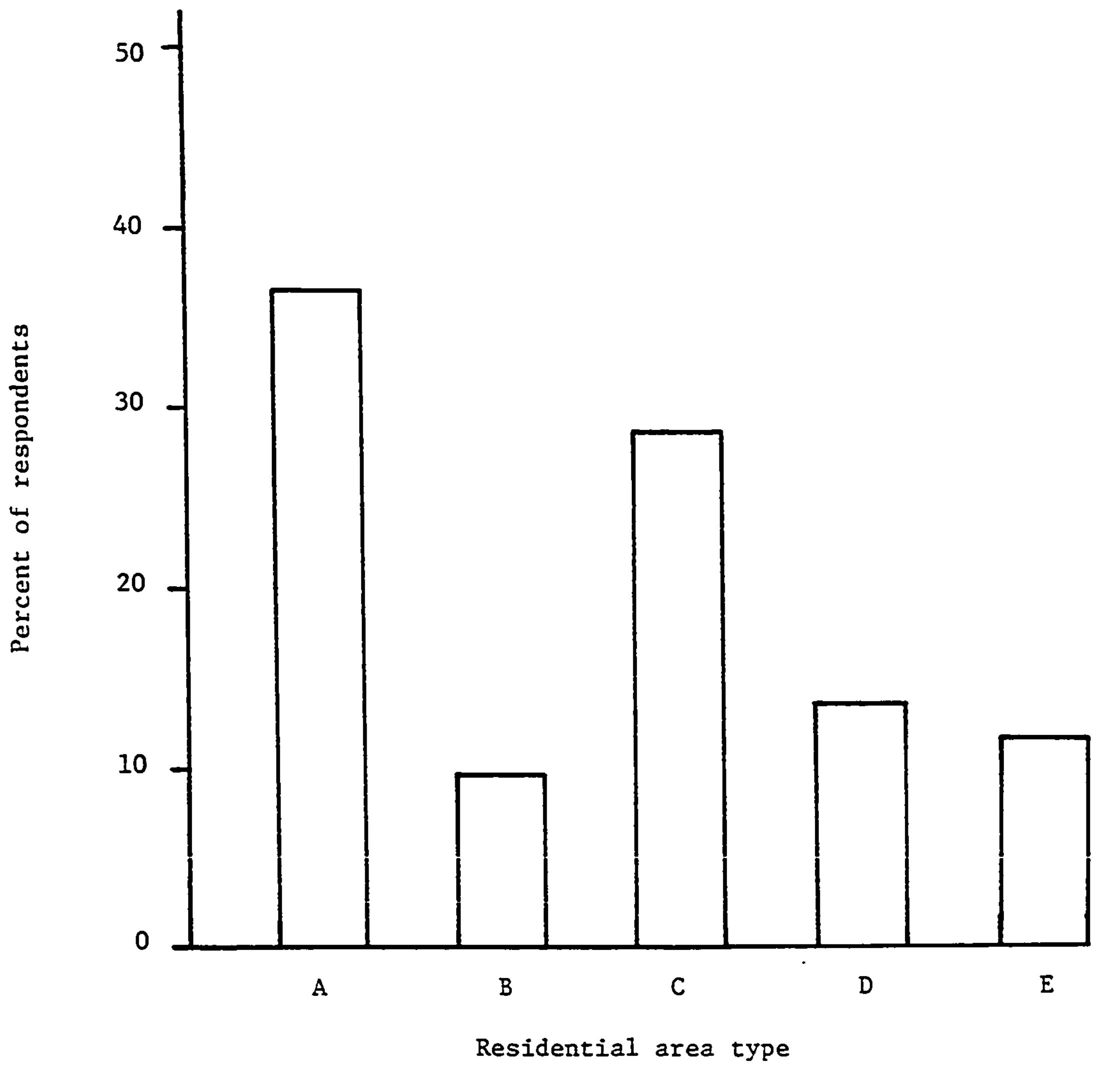


FIGURE 9. Respondent profile -- age



A: Urban area, city or near suburbs
B: Urban area, outlying suburbs or surrounding towns
C: Smaller city, urban in character
D: Small town (under 2,500 population)
E: Rural area

FIGURE 10. Respondent profile -- residential area type

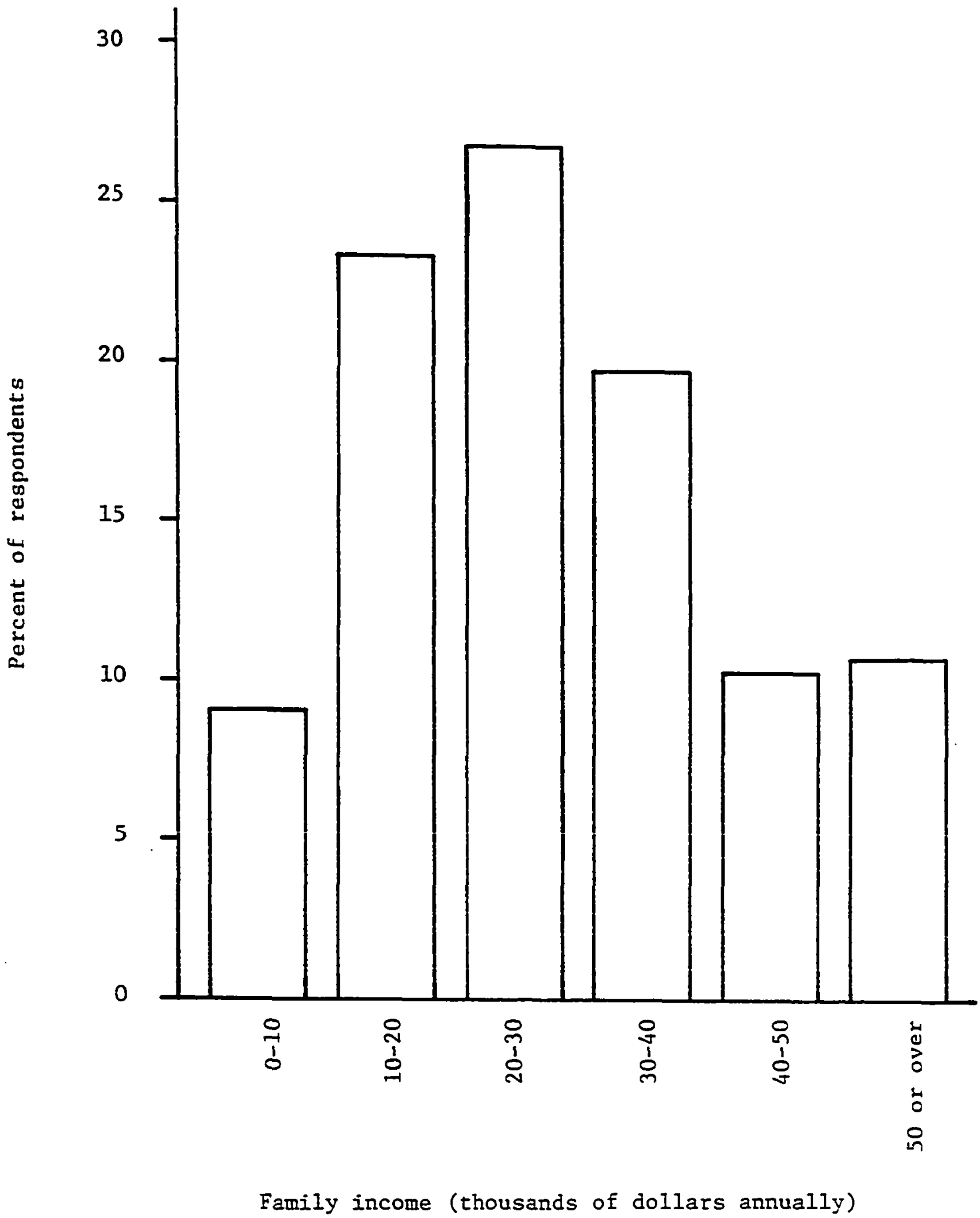


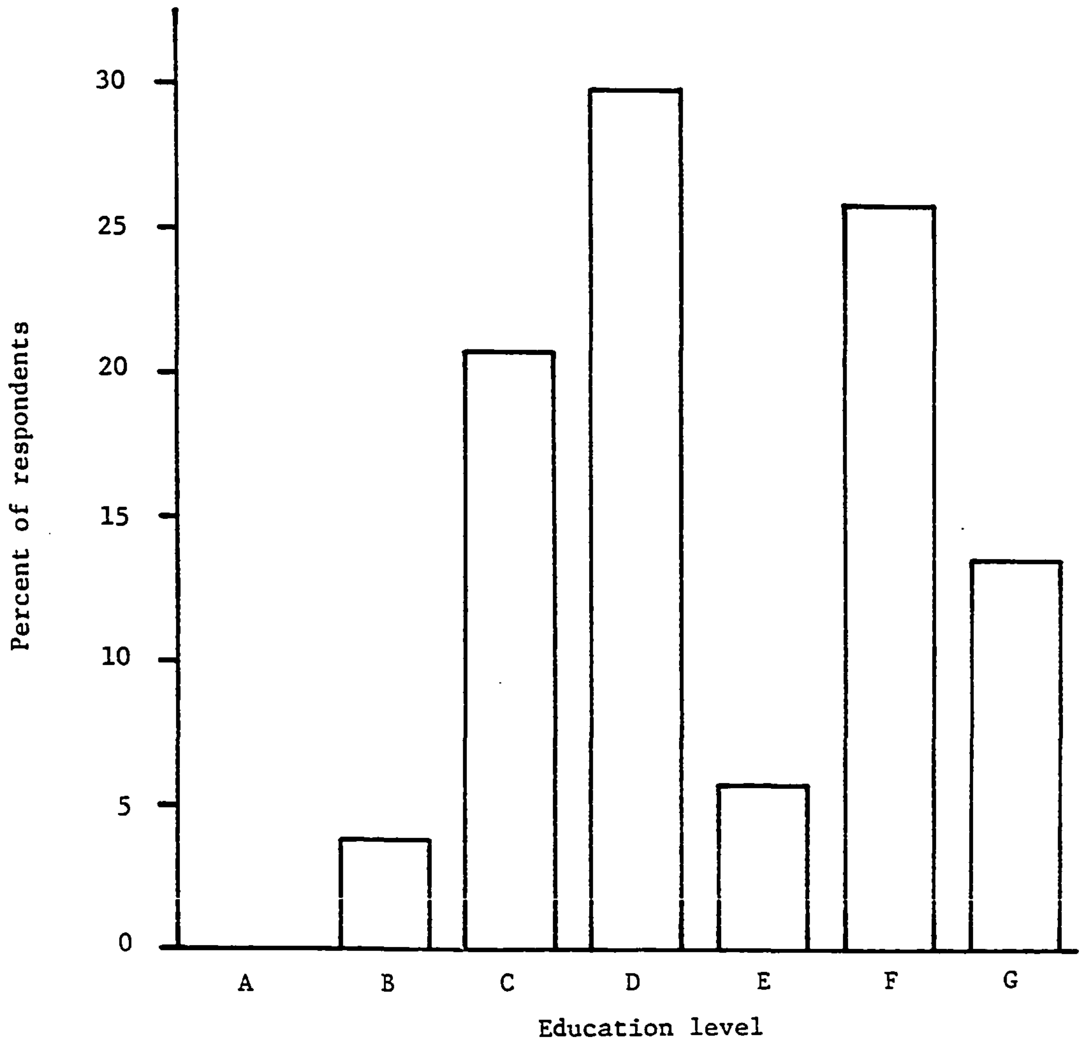
FIGURE 11. Respondent profile -- family income

representation in the sample is the associate degree, with only about five percent. The remaining categories are all well represented.

Though the age at which a driver first receives a license to drive is not directly a measure of driving experience, the information from responses to this question can be combined with information on age to determine number of years of driving experience. The information in Figure 13 verifies the expectation that most drivers in the sample received their first license at 16 years of age. This means that the number of years of driving experience for a driver may be no more useful for the objectives of this study than the use of the driver's age.

Driver education is a variable that is readily identifiable as related to driving experience. This is looked at from two distinct viewpoints. First, there is the question of whether a driver education course was taken by the respondent. The majority of drivers responding, 65.17 percent, took a driver education course. Of course, that means that the sample of those who did not is quite sufficient for purposes of analysis -- nearly 180 drivers responded that they did not take such a course.

Those that took a driver education course were asked how long it had been since taking the course. The mean value of the responses to this question was 12.9 years. A careful look at the results of time since driver education, plotted in Figure 14, along with the ages in Figure 9, reveals these two plots to be nearly parallel. Thus, time since driver education may be another variable of no more practical use to this study than the ages of the respondents.



A: Less than 8th Grade
B: 8th Grade through some high school
C: High school graduate
D: Some college (less than Bachelor's degree)
E: Associate degree
F: Bachelor's degree
G: Advanced or professional degree

FIGURE 12. Respondent profile -- education

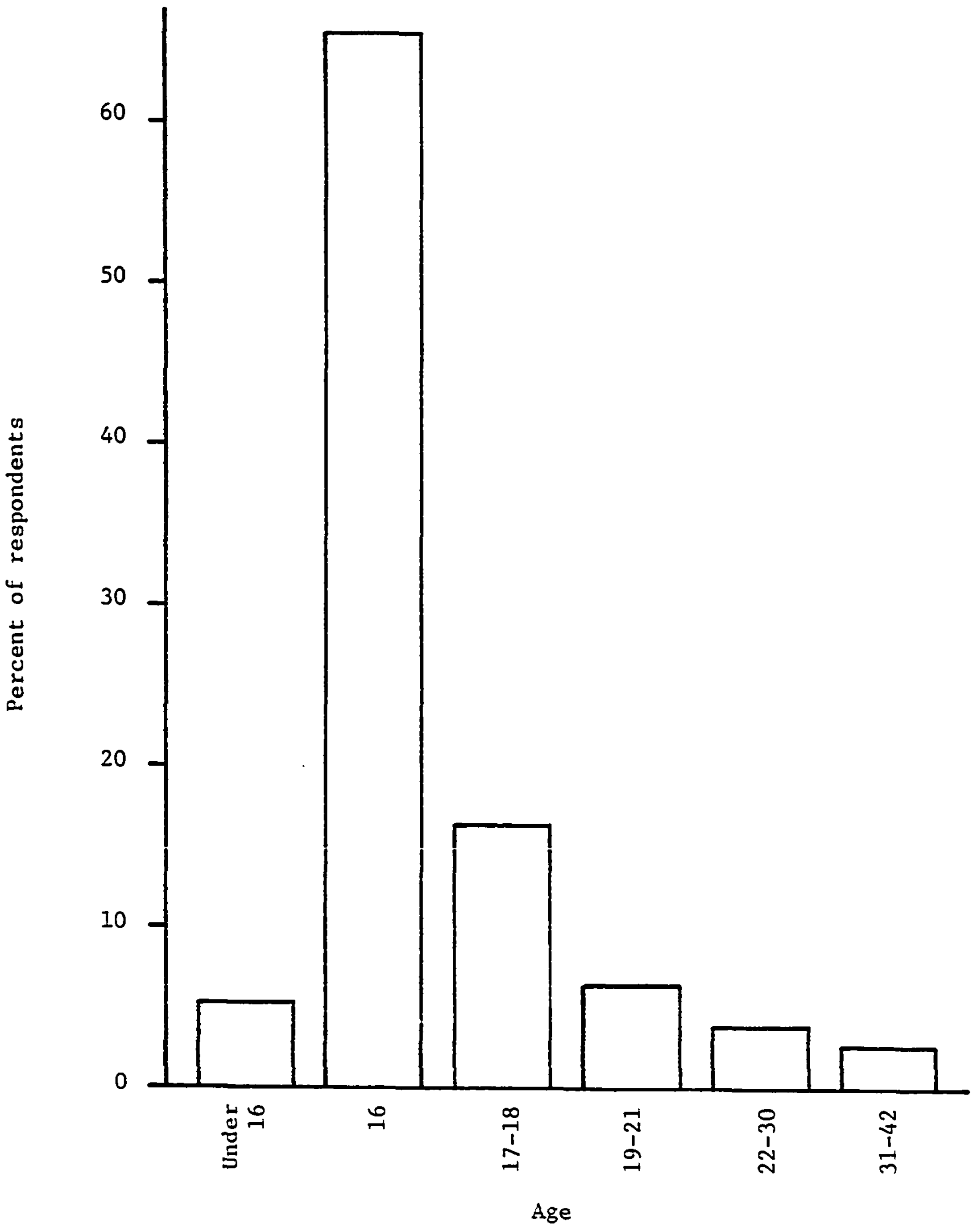


FIGURE 13. Respondent profile -- age at first license issue

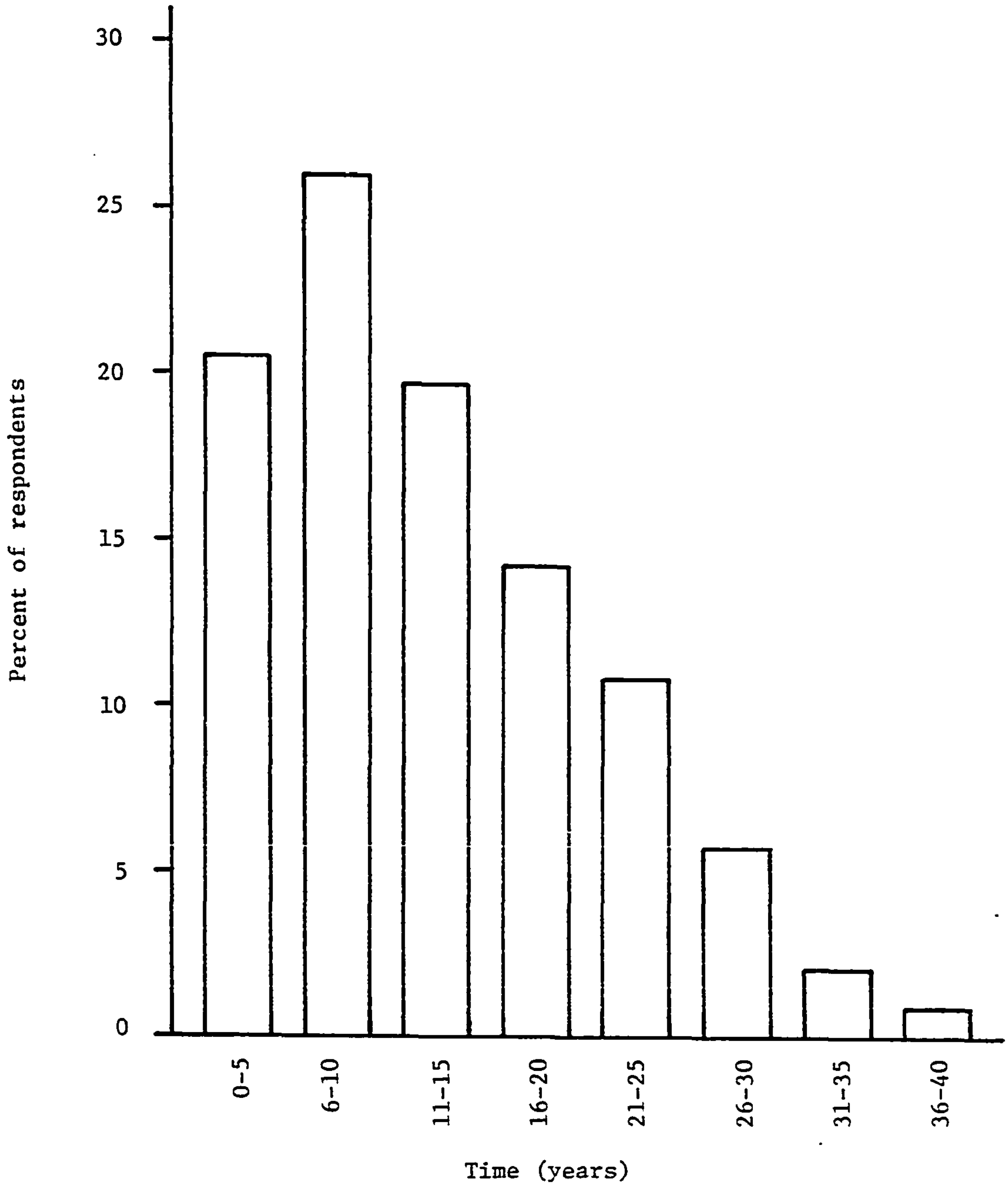


FIGURE 14. Respondent profile -- time since driver education

Another variable related to driving experience is the annual mileage driven by the respondent, as seen in Figure 15. There were not a great number of drivers in the sample claiming to drive over 20,000 miles annually. The majority of respondents indicated a driving mileage of between 5,000 and 15,000 miles annually.

Though driving on gravel roads is not likely to come readily to mind when considering measures of driving experience, for reasons given before in the section on questionnaire development, it may be of interest in this study. The mean of the values given in response to the question on the percentage of gravel road driving, as plotted in Figure 16, was 8.56 percent. These values indicate the majority of drivers responding do five percent or less of their driving on gravel roads. About one-third of the respondents gave a zero or one percent response to this question. This variable could prove to be of limited utility for further study due to the small portion of the sample with extensive gravel road driving experience.

Two questions of a more sensitive nature were asked with regard to driving experience. First, drivers were asked if their license had ever been revoked or suspended. Only 4.02 percent of the respondents gave a positive response to this question. Second, drivers were asked to indicate if they had been involved, as a driver, in a motor vehicle accident in the past two years. There were 15.52 percent positive responses to this question. Clearly, the second of these questions is of greater interest in this study due to the greater availability of positive responses.

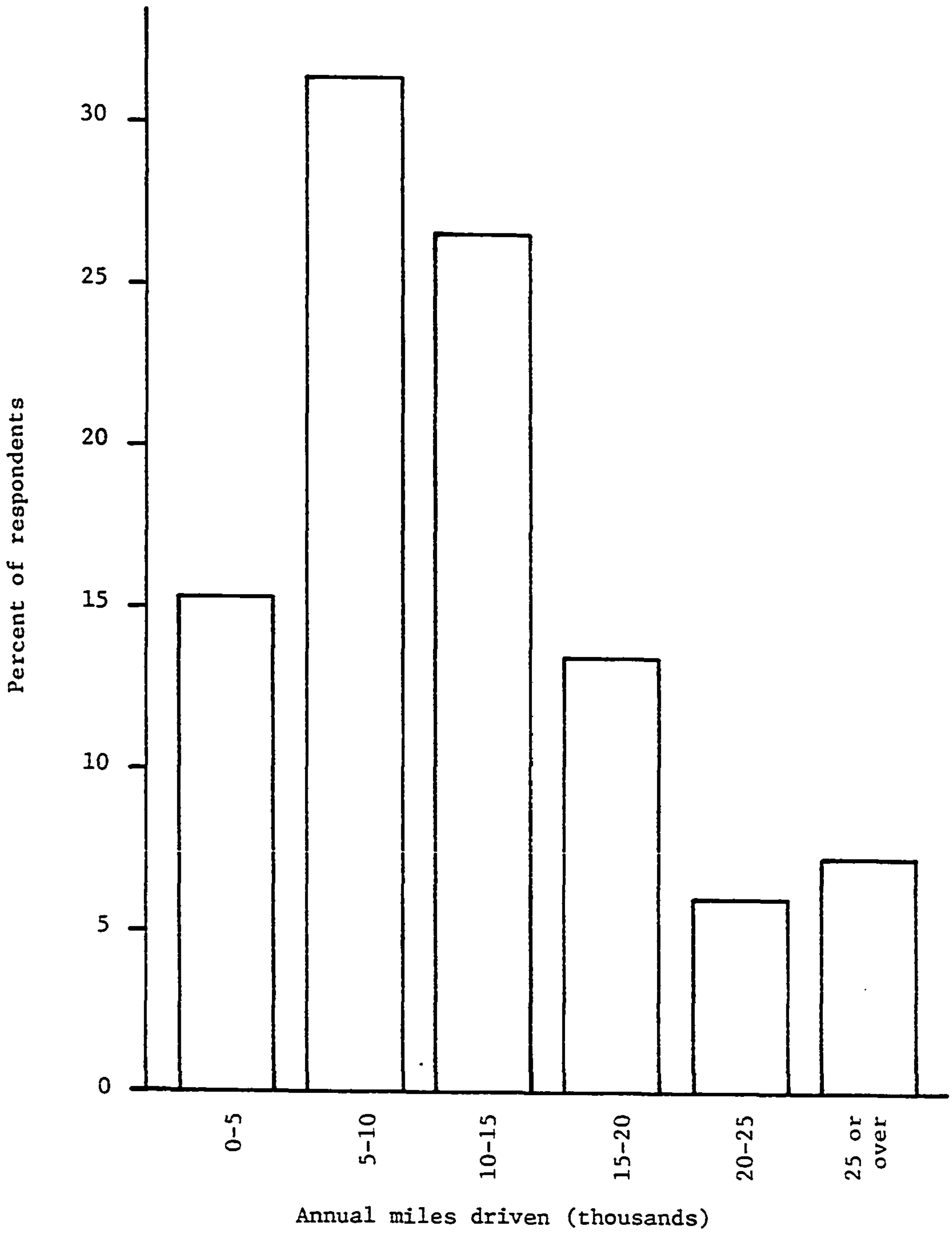


FIGURE 15. Respondent profile -- annual mileage driven

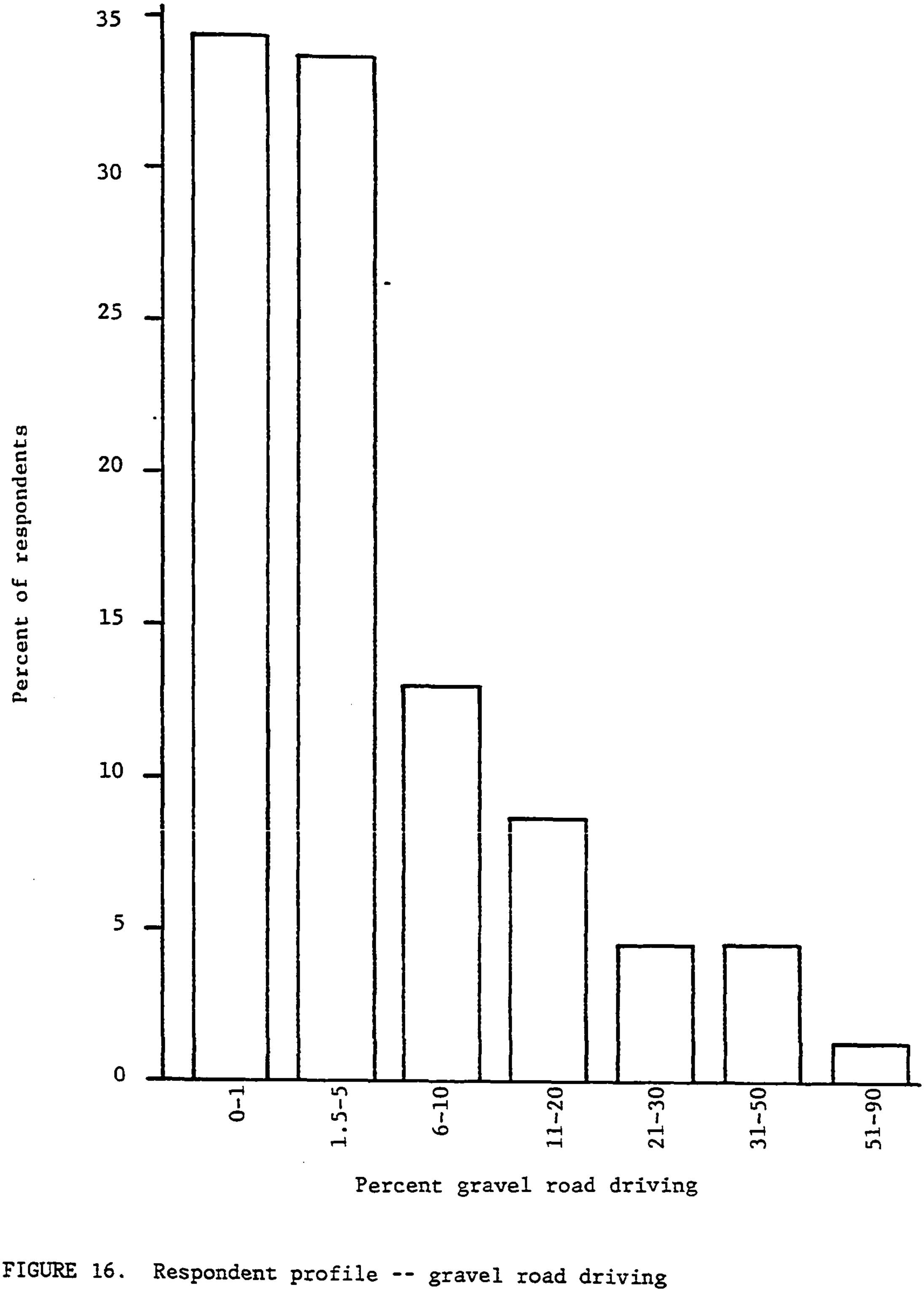


FIGURE 16. Respondent profile -- gravel road driving

Method of presenting data

As the next step in analysis of the questionnaire returns, tests were performed on the data to determine whether certain variables were independent of each other. Data were presented in contingency tables and the variables used were tested for independence using the chi-square test. This particular analytical technique was used because it is commonly used and understood for such tests of independence, and because it is readily available on many computer software packages.

The tables presented in the following material are reasonably straightforward, but require some initial explanation. They are similar, as presented, to those directly output from computer runs, but the statistical information presented has been reduced to only the simplest information to avoid a cluttered, confusing appearance. The continuity adjusted chi-square values, applicable to 2X2 tables, have been omitted. If this value should prove to be of interest in a particular case, it will be presented in the text. Probability values for Fisher's exact test, applicable when expected cell frequencies are less than five, have also been omitted, and will be presented in the text when necessary. Rows and columns applicable to missing responses have also been omitted.

Another change in the tables to improve their readability was the addition of enhanced row and column labels. Most of the labels so added are self explanatory, but a few refer to the questionnaire directly, causing the need for some explanation. One such label used repeatedly is "Response to question 20." Question 20 is the central question in this entire study: in Figure 3, referring to a T intersection, "Which vehicle has the right-of-way?" Another question referred to in a label as well as in several table titles is question 11. This is the four-legged intersection control question corresponding to question 20: in Figure 5, "Which vehicle has the right-of-way?" Note that vehicle B, the turning vehicle to the right of vehicle A, has the right-of-way in both these instances.

Answers to questions 11 and 20

In Table 3, responses to questions 11 and 20 are tested for independence. The 0.0001 probability of the distribution shown occurring by chance suggests the responses are not independent, and it is interesting to note that only 13 of 487 respondents to these questions answered question 20 correctly while incorrectly answering question 11. Nearly 40 percent of the respondents answered both of these questions incorrectly, providing little conclusive information about the main hypothesis of this study. Another noteworthy observation that can be made from this table is the overwhelming tendency for respondents to answer both questions correctly or both questions incorrectly. This was the case for over two-thirds of the respondents.

The results from Table 3 that are of greatest interest in this study are those in the second row of the table. The responses represented in that row for question 20 are only from those respondents answering question 11 correctly, thus "filtering out" respondents that

TABLE 3. Contingency table: responses to right-of-way questions 11 and 20

RESPONSE TO QUESTION 11	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	RESPONSE TO QUESTION 20: A	B	TOTAL
	A	188 137.4 50.6 18.6 38.60 93.53 56.46	13 63.6 -50.6 40.2 2.67 6.47 8.44	201 41.27
	B	145 195.6 -50.6 13.1 29.77 50.70 43.54	141 90.4 50.6 28.3 28.95 49.30 91.56	286 58.73
	TOTAL	333 68.38	154 31.62	487 100.00

CHI-SQUARE = 100.158
DF = 1
PROB = 0.0001

could have based their response to question 20 on requiring the turning vehicle to yield. Of the responses on that row, 50.70 percent answered question 20 incorrectly. Using the standard normal distribution to calculate a 95 percent confidence interval for that percentage results in the finding that the true value lies between 44.91 and 56.49 percent.

The percentage of respondents incorrectly answering question 20 without consideration of their response to question 11 is higher than that, as might be expected. Of the 487 responses in the table, 333, or 68.38 percent, were incorrect for question 20. Again calculating a 95 percent confidence interval, the true value of this statistic is seen to lie between 64.25 and 72.51 percent. A separate computation was performed similar to that indicated in Table 3 using only respondents who answered questions 14 and 17 correctly. These questions are the "Which vehicle has the right-of-way?" questions associated with Figures 4 and 6, where the turning vehicle must yield the right-of-way, and, as expected, were answered incorrectly by very few respondents. As a result, this separate computation produced statistics that agreed very closely with those from Table 3.

Time questionnaire held before mailing

In order to evaluate the impact of allowing the questionnaires to be taken by the respondents and mailed at their convenience on the responses to questions related to the main hypothesis of this study, a special variable was created containing information on the length of time the questionnaire was held by the respondent before mailing. The value of this variable was determined by using the date from the postmark on the returned questionnaire and the date questionnaires were distributed at the site indicated by the site code lettered on the questionnaire. These values were then classified into classes of low, medium, and high by choosing values resulting in about one-third of the sample falling in each class. A value of zero or one day was classified as low, two, three, or four days were classified as medium, and five or more days resulted in a high classification. The probability value of 0.5910 given in Table 4 means the distribution of responses shown is likely a chance occurrence and that responses to question 20 and the time questionnaires were held before mailing are probably independent. Similar analyses performed on subsets of the main data set formed by using only those answers from respondents answering question 11 correctly, then incorrectly, respectively, gave substantially the same result. Apparently, the likelihood of a correct response to question 20 was unrelated to the time taken to answer the question.

The fact that a large percentage of respondents did answer question 20 incorrectly calls for tests to determine if question 20 responses are independent of the driving experience and socio-economic variables measured. Further, if a lack of independence is noted, the relationship between the non-independent variables should be studied. In the following material, these tests of independence will be discussed briefly, with note of additional tests performed on subsets of the main data set.

Annual driving mileage

In Table 5, the mileage level indications are those used on the questionnaire and detailed previously in Figure 15, 0-5,000, 5,000-10,000, and so forth. The probability value of 0.5424 indicates that the distribution of responses shown in the table is likely a chance

TABLE 4. Contingency table: response to question 20 versus time questionnaire held before mailing

RESPONSE TO QUESTION 20 (FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT)	CLASSIFICATION OF TIME QUESTIONNAIRE HELD BEFORE MAILING: LOW	MEDIUM	HIGH	TOTAL
A	112 109.9 2.1 0.0 23.38 33.84 70.44	114 111.3 2.7 0.1 23.80 34.44 70.81	105 109.9 -4.9 0.2 21.92 31.72 66.04	331 69.10
B	47 49.1 -2.1 0.1 9.81 31.76 29.56	47 49.7 -2.7 0.2 9.81 31.76 29.19	54 49.1 4.9 0.5 11.27 36.49 33.96	148 30.90
TOTAL	159 33.19	161 33.61	159 33.19	479 100.00

CHI-SQUARE = 1.052
DF = 2
PROB = 0.5910

occurrence. Similar results were obtained from data subsets based on correct and incorrect responses to question 11. Driving mileage does not seem to affect responses to question 20, regardless of the correctness of answers to question 11.

Table 5. Contingency table: response to question 20 versus annual driving mileage level

RESPONSE TO QUESTION 20 (FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT)	MILEAGE LEVEL A	B	C	D	E	F	TOTAL
A	52 50.1 1.9 0.1 10.79 15.71 71.23	105 104.4 0.6 0.0 21.78 31.72 69.08	93 87.2 5.8 0.4 19.29 28.10 73.23	42 45.3 -3.3 0.2 8.71 12.69 63.64	18 19.9 -1.9 0.2 3.73 5.44 62.07	21 24.0 -3.0 0.4 4.36 6.34 60.00	331 68.67
B	21 22.9 -1.9 0.2 4.36 13.91 28.77	47 47.6 -0.6 0.0 9.75 31.13 30.92	34 39.8 -5.8 0.8 7.05 22.52 26.77	24 20.7 3.3 0.5 4.98 15.89 36.36	11 9.1 1.9 0.4 2.28 7.28 37.93	14 11.0 3.0 0.8 2.90 9.27 40.00	151 31.33
TOTAL	73 15.15	152 31.54	127 26.35	66 13.69	29 6.02	35 7.26	482 100.00

CHI-SQUARE = 4.049
DF = 5
PROB = 0.5424

Accident history

Table 6 indicates that responses to question 20 and accident history are probably independent. In this case, the continuity adjusted chi-square value, 0.797, gives an even stronger case for independence, with a probability value of 0.3721. Analyses performed on data subsets based on correct and incorrect responses to question 11 produced similar results to those above, reinforcing the finding of independence, since the results are obtained regardless of response to question 11. Accident history apparently has no affect on responses to question 20.

Driver's license history

Table 7 indicates that the response to question 20 and whether the driver's license had ever been revoked or suspended are probably independent. The continuity adjusted chi-square value, 0.134, results in a probability value of 0.7144, an even stronger case for independence of the variables. Again, similar results were obtained using the data subsets for correct and incorrect responses to question 11. The loss of driving privilege apparently does not affect the likelihood of a correct response to question 20, regardless of the driver's response to question 11.

Gravel road driving experience

Gravel road driving experience was classified as low, medium, or high based on one percent or less being low, more than five percent being high, and all other responses being classed as medium. This

TABLE 6. Contingency table: response to question 20 versus accident history

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	ACCIDENT IN PAST 2 YEARS? NO	YES	TOTAL
	A	276 279.8 -3.8 0.1 57.74 83.38 68.32	55 51.2 3.8 0.3 11.51 16.62 74.32	331 69.25
	B	128 124.2 3.8 0.1 26.78 87.07 31.68	19 22.8 -3.8 0.6 3.97 12.93 25.68	147 30.75
	TOTAL	404 84.52	74 15.48	478 100.00

CHI-SQUARE = 1.060
DF = 1
PROB = 0.3032

resulted in classes with nearly equal numbers of responses. Table 8 indicates that gravel road driving experience and response to question 20 are probably independent. This is not a surprising result in light of the comments made previously in discussing Figure 16. The existence

TABLE 7. Contingency table: response to question 20 versus driver's license history

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	LICENSE REVOKED OR SUSPENDED? NO	YES	TOTAL
	A	309 310.2 -1.2 0.0 65.61 95.37 68.51	15 13.8 1.2 0.1 3.18 4.63 75.00	324 68.79
	B	142 140.8 1.2 0.0 30.15 96.60 31.49	5 6.2 -1.2 0.2 1.06 3.40 25.00	147 31.21
	TOTAL	451 95.75	20 4.25	471 100.00

CHI-SQUARE = 0.375
DF = 1
PROB = 0.5402

of a relationship between responses to question 20 and gravel road driving experience cannot be concluded from these results, but such a relationship could be obscured by the shortage of respondents with significant gravel road driving experience.

TABLE 8. Contingency table: response to question 20 versus gravel road driving experience

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	CLASSIFICATION OF PERCENTAGE OF GRAVEL ROAD DRIVING: LOW	MEDIUM	HIGH	TOTAL
	A	110 110.8 -0.8 0.0 23.01 33.64 67.90	113 110.1 2.9 0.1 23.64 34.56 70.19	104 106.0 -2.0 0.0 21.76 31.80 67.10	327 68.41
	B	52 51.2 0.8 0.0 10.88 34.44 32.10	48 50.9 -2.9 0.2 10.04 31.79 29.81	51 49.0 2.0 0.1 10.67 33.77 32.90	151 31.59
	TOTAL	162 33.89	161 33.68	155 32.43	478 100.00

CHI-SQUARE = 0.378
DF = 2
PROB = 0.8277

Age

Age classes used in Table 9 did not result in equal size classes, but there is adequate representation in each class for a valid analysis. The classes were defined with ages 16 to 30 being low, 31 to 50 being medium, and over 50 being high. It is seen in this table that age and response to question 20 are probably not independent, with a probability of 0.0001 that the distribution of responses given would be a chance occurrence. This indicates that a relationship may exist between these variables.

TABLE 9. Contingency table: response to question 20 versus age for all respondents

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	AGE CLASSIFICATION LOW	MEDIUM	HIGH	TOTAL
	A	174 143.2 30.8 6.6 36.02 52.57 83.25	108 116.5 -8.5 0.6 22.36 32.63 63.53	49 71.3 -22.3 7.0 10.14 14.80 47.12	331 68.53
	B	35 65.8 -30.8 14.4 7.25 23.03 16.75	62 53.5 8.5 1.4 12.84 40.79 36.47	55 32.7 22.3 15.2 11.39 36.18 52.88	152 31.47
	TOTAL	209 43.27	170 35.20	104 21.53	483 100.00

CHI-SQUARE = 45.094
DF = 2
PROB = 0.0001

As seen in Table 10, a similar result is obtained using the data subset for correct responses to question 11. If a relationship exists between age and response to question 20, it apparently is verified for those drivers in the sample who answered question 11 correctly.

TABLE 10. Contingency table: response to question 20 versus age for respondents answering question 11 correctly

	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	AGE CLASSIFICATION LOW	MEDIUM	HIGH	TOTAL
RESPONSE TO QUESTION 20	A	72 51.7 20.3 7.9 25.71 50.70 70.59	56 58.3 -2.3 0.1 20.00 39.44 48.70	14 31.9 -17.9 10.1 5.00 9.86 22.22	142 50.71
	B	30 50.3 -20.3 8.2 10.71 21.74 29.41	59 56.7 2.3 0.1 21.07 42.75 51.30	49 31.0 18.0 10.4 17.50 35.51 77.78	138 49.29
	TOTAL	102 36.43	115 41.07	63 22.50	280 100.00

CHI-SQUARE = 36.767
DF = 2
PROB = 0.0001

In Table 11, a different result is obtained. With a probability of 0.2264 that the given distribution of responses is a chance occurrence, the variables age and response to question 20 are probably independent for this data subset. Apparently, the driver inclined to incorrectly respond to question 11 is also inclined to incorrectly respond to question 20, regardless of age. Of the 199 responses to question 20 represented in this table, only 13 are correct.

Driving experience

Years of driving experience were classified for Table 12 as low: 0-10 years, medium: 11-25 years, and high: over 25 years. The resulting classes are very nearly the same size. As seen from the table, the probability that the distribution of responses shown is a chance occurrence is 0.0001, indicating that these variables are probably not independent. Thus, a relationship may exist between response to question 20 and driving experience.

A similar result is obtained from Table 13 for the data subset for correct responses to question 11. Any relationship existing between driving experience and response to question 20 for the main data set is likely to also exist for that subset of drivers correctly answering question 11.

Analysis of the data subset for incorrect responses to question 11 again results in a differing result from that for the main data set. Table 14 shows a probability value of 0.4304, indicating that the distribution of responses shown is likely a chance occurrence and these

TABLE 11. Contingency table: response to question 20 versus age for respondents answering question 11 incorrectly

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	AGE CLASSIFICATION LOW	 MEDIUM	 HIGH	 TOTAL
	A	101 99.1 1.9 0.0 50.75 54.30 95.28	50 49.5 0.5 0.0 25.13 26.88 94.34	35 37.4 -2.4 0.2 17.59 18.82 87.50	186 93.47
	B	5 6.9 -1.9 0.5 2.51 38.46 4.72	3 3.5 -0.5 0.1 1.51 23.08 5.66	5 2.6 2.4 2.2 2.51 38.46 12.50	13 6.53
	TOTAL	106 53.27	53 26.63	40 20.10	199 100.00

CHI-SQUARE = 2.971
DF = 2
PROB = 0.2264

variables are probably independent for this data subset. Years of driving experience apparently have no effect on responses to question 20 for those drivers responding incorrectly to question 11.

TABLE 12. Contingency table: response to question 20 versus driving experience for all respondents

CLASSIFICATION BY YEARS OF DRIVING EXPERIENCE

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	LOW	MEDIUM	HIGH	TOTAL
	A	132 108.8 23.2 5.0 27.79 40.37 83.54	121 123.2 -2.2 0.0 25.47 37.00 67.60	74 95.0 -21.0 4.6 15.58 22.63 53.62	327 68.84
	B	26 49.2 -23.2 11.0 5.47 17.57 16.46	58 55.8 2.2 0.1 12.21 39.19 32.40	64 43.0 21.0 10.3 13.47 43.24 46.38	148 31.16
	TOTAL	158 33.26	179 37.68	138 29.05	475 100.00

CHI-SQUARE = 30.953
DF = 2
PROB = 0.0001

Driver education

A casual glance at Table 15 could lead to an erroneous conclusion. The statistics from the table indicate that the distribution of responses shown is unlikely to occur by chance, with a probability of

TABLE 13. Contingency table: response to question 20 versus driving experience for respondents answering question 11 correctly

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	CLASSIFICATION BY YEARS OF DRIVING EXPERIENCE LOW	MEDIUM	HIGH	TOTAL
	A	53 38.1 14.9 5.9 19.20 37.32 71.62	58 58.1 -0.1 0.0 21.01 40.85 51.33	31 45.8 -14.8 4.8 11.23 21.83 34.83	142 51.45
	B	21 35.9 -14.9 6.2 7.61 15.67 28.38	55 54.9 0.1 0.0 19.93 41.04 48.67	58 43.2 14.8 5.1 21.01 43.28 65.17	134 48.55
	TOTAL	74 26.81	113 40.94	89 32.25	276 100.00

CHI-SQUARE = 21.895
DF = 2
PROB = 0.0001

only 0.0001. Thus, a relationship between driver education and response to question 20 may reasonably be expected to exist.

However, the nature of that relationship may be unexpected. A close study of the individual cells in the table reveals that incorrect

TABLE 14. Contingency table: response to question 20 versus driving experience for respondents answering question 11 incorrectly

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	CLASSIFICATION BY YEARS OF DRIVING EXPERIENCE LOW	 MEDIUM	 HIGH	 TOTAL
	A	78 77.5 0.5 0.0 40.00 42.86 93.98	62 60.7 1.3 0.0 31.79 34.07 95.38	42 43.9 -1.9 0.1 21.54 23.08 89.36	182 93.33
	B	5 5.5 -0.5 0.1 2.56 38.46 6.02	3 4.3 -1.3 0.4 1.54 23.08 4.62	5 3.1 1.9 1.1 2.56 38.46 10.64	13 6.67
	TOTAL	83 42.56	65 33.33	47 24.10	195 100.00

CHI-SQUARE = 1.686
DF = 2
PROB = 0.4304

responses were higher than expected for drivers who had a driver education course and lower than expected for drivers who had not had a driver education course. Further, correct responses were higher than expected for drivers who had not had a driver education course and lower

TABLE 15. Contingency table: response to question 20 versus driver education for all respondents

RESPONSE TO QUESTION 20 FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	DRIVER EDUCATION COURSE TAKEN? NO	YES	TOTAL
A	84 107.0 -23.0 5.0 17.46 25.45 53.85	246 223.0 23.0 2.4 51.14 74.55 75.69	330 68.61
B	72 49.0 23.0 10.8 14.97 47.68 46.15	79 102.0 -23.0 5.2 16.42 52.32 24.31	151 31.39
TOTAL	156 32.43	325 67.57	481 100.00

CHI-SQUARE = 23.357
DF = 1
PROB = 0.0001

than expected for drivers who had a driver education course. Since this is a surprising result, it will subsequently be covered in further detail in an attempt to find a causal relationship.

Table 16 shows that similar results to those reported above are obtained for the data subset for correct responses to question 11. Again, the results for the subset of drivers answering question 11 reinforce those for the main data set.

TABLE 16. Contingency table: response to question 20 versus driver education for respondents answering question 11 correctly

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	DRIVER EDUCATION COURSE TAKEN? NO	 YES	 TOTAL
	A	31 49.0 -18.0 6.6 11.07 21.68 32.29	112 94.0 18.0 3.5 40.00 78.32 60.87	143 51.07
	B	65 47.0 18.0 6.9 23.21 47.45 67.71	72 90.0 -18.0 3.6 25.71 52.55 39.13	137 48.93
	TOTAL	96 34.29	184 65.71	280 100.00

CHI-SQUARE = 20.618
DF = 1
PROB = 0.0001

Table 17 reveals that, once again, those respondents answering question 11 incorrectly are unlikely to answer question 20 correctly regardless of other factors, with only 13 correct responses of 197. In this case, it is driver education that must be considered independent of response to question 20 for the indicated data subset. The probability value of 0.1566 given in the table indicates that the distribution of responses shown is probably a chance occurrence.

Time since driver education was classified for Table 18 and other following analyses as low: 0-5 years, medium: 6-15 years, and high: over 15 years. That table reveals that, with the probability of the given distribution occurring by chance being 0.0001, the variables in the table are probably not independent. A relationship may exist between response to question 20 and time since driver education.

Table 19 shows a similar result for the data subset for correct responses to question 11. The significance level is somewhat different in this case, being 0.0052, nevertheless a highly significant result.

There were only seven correct responses to question 20 from the 139 respondents in Table 20 who answered question 11 incorrectly. As indicated in that table, response to question 20 and time since driver education are probably independent for this data subset for any meaningful significance level considered.

Driver education and age

In an attempt to determine why driver education produced the results noted previously when tested for independence from question 20

TABLE 17. Contingency table: response to question 20 versus driver education for respondents answering question 11 incorrectly

FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	DRIVER EDUCATION COURSE TAKEN? NO	 YES	 TOTAL
RESPONSE TO QUESTION 20: A	51 53.2 -2.2 0.1 25.89 27.72 89.47	133 130.8 2.2 0.0 67.51 72.28 95.00	184 93.40
B	6 3.8 2.2 1.3 3.05 46.15 10.53	7 9.2 -2.2 0.5 3.55 53.85 5.00	13 6.60
TOTAL	57 28.93	140 71.07	197 100.00

CHI-SQUARE = 2.007
DF = 1
PROB = 0.1566

responses, it was also tested for independence from age, using the three classes of age previously reported. In Table 21, it can be seen that age and driver education are probably not independent, with only a 0.0001 probability of the distribution shown being a chance occurrence.

TABLE 18. Contingency table: response to question 20 versus time since driver education for all respondents

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	CLASSIFICATION BY TIME SINCE DRIVER EDUCATION LOW	MEDIUM	HIGH	TOTAL
A		56 50.6 5.4 0.6 17.34 22.95 83.58	122 111.8 10.2 0.9 37.77 50.00 82.43	66 81.6 -15.6 3.0 20.43 27.05 61.11	244 75.54
B		11 16.4 -5.4 1.8 3.41 13.92 16.42	26 36.2 -10.2 2.9 8.05 32.91 17.57	42 26.4 15.6 9.2 13.00 53.16 38.89	79 24.46
TOTAL		67 20.74	148 45.82	108 33.44	323 100.00

CHI-SQUARE = 18.320
DF = 2
PROB = 0.0001

A review of the individual cells in the table reveals that younger respondents are more likely to have taken driver education than would be expected under the independent hypothesis, while older respondents are less likely to have taken driver education. Thus, the surprising

TABLE 19. Contingency table: response to question 20 versus time since driver education for respondents answering question 11 correctly

FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	CLASSIFICATION BY TIME SINCE DRIVER EDUCATION LOW	MEDIUM	HIGH	TOTAL
RESPONSE TO QUESTION 20: A	19 15.8 3.2 0.7 10.38 17.12 73.08	57 49.7 7.3 1.1 31.15 51.35 69.51	35 45.5 -10.5 2.4 19.13 31.53 46.67	111 60.66
RESPONSE TO QUESTION 20: B	7 10.2 -3.2 1.0 3.83 9.72 26.92	25 32.3 -7.3 1.6 13.66 34.72 30.49	40 29.5 10.5 3.7 21.86 55.56 53.33	72 39.34
TOTAL	26 14.21	82 44.81	75 40.98	183 100.00

CHI-SQUARE = 10.526
DF = 2
PROB = 0.0052

relationship between driver education and response to question 20 may be explained in terms of this relationship between age and driver education. Because older drivers have been shown to be more likely to respond correctly to question 20, and because older drivers have been

TABLE 20. Contingency table: response to question 20 versus time since driver education for respondents answering question 11 incorrectly

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	CLASSIFICATION BY TIME SINCE DRIVER EDUCATION LOW	MEDIUM	HIGH	TOTAL
	A	37 38.9 -1.9 0.1 26.62 28.03 90.24	64 61.7 2.3 0.1 46.04 48.48 98.46	31 31.3 -0.3 0.0 22.30 23.48 93.94	132 94.96
	B	4 2.1 1.9 1.8 2.88 57.14 9.76	1 3.3 -2.3 1.6 0.72 14.29 1.54	2 1.7 0.3 0.1 1.44 28.57 6.06	7 5.04
	TOTAL	41 29.50	65 46.76	33 23.74	139 100.00

CHI-SQUARE = 3.645
DF = 2
PROB = 0.1616

shown to be less likely to have taken driver education, drivers who have taken driver education may be expected to be younger and not to be as likely to respond correctly to question 20 as those who have not taken driver education. Similar results were obtained from the data subsets for correct and incorrect responses to question 11.

TABLE 21. Contingency table: age versus driver education

AGE CLASSIFICATION	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	DRIVER EDUATION COURSE TAKEN? NO	YES	TOTAL
	LOW	11 73.4 -62.4 53.0 2.16 5.21 6.21	200 137.6 62.4 28.3 39.29 94.79 60.24	211 41.45
	MEDIUM	51 60.9 -9.9 1.6 10.02 29.14 28.81	124 114.1 9.9 0.9 24.36 70.86 37.35	175 34.38
	HIGH	115 42.8 72.2 122.0 22.59 93.50 64.97	8 80.2 -72.2 65.0 1.57 6.50 2.41	123 24.17
	TOTAL	177 34.77	332 65.23	509 100.00

CHI-SQUARE = 270.732
DF = 2
PROB = 0.0001

Residential area types

Residential area types used for the analysis represented in Table 22 are the same as those used on the questionnaire and reported previously in Figure 10. As seen in the table, residential area type and response to question 20 should be considered independent for any meaningful level of significance considered.

Family income

Table 23 uses the same income classes as reported previously in Figure 11 and as used on the questionnaire. The results in the table indicate that the variables therein should be considered independent for any meaningful level of significance considered.

Education

The classes used for education level in Table 24 are the same as those reported previously in Figure 12 and used on the questionnaire. As seen in the table, the probability level for the test of independence of education and response to question 20 is 0.0905, a marginally significant value. More importantly, over half of the chi-square total is from the "G", or graduate degree, column. This suggests need for a further study of responses of drivers with advanced education.

In further analyses, the relationship between education level and the response to question 20 was examined, based on responses to question 11. Data for those respondents who answered question 11 correctly are displayed in Table 25. Table 26 displays the comparable data for

TABLE 22. Contingency table: response to question 20 versus residential area type

RESPONSE TO QUESTION 20	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	RESIDENTIAL AREA TYPE A	B	C	D	E	TOTAL
A	FREQUENCY	116	36	101	41	34	328
	EXPECTED	118.0	30.9	96.8	45.3	37.1	
	DEVIATION	-2.0	5.1	4.2	-4.3	-3.1	
	CELL CHI2	0.0	0.8	0.2	0.4	0.3	
	PERCENT	24.27	7.53	21.13	8.58	7.11	68.62
	ROW PCT	35.37	10.98	30.79	12.50	10.37	
	COL PCT	67.44	80.00	71.63	62.12	62.96	
B	FREQUENCY	56	9	40	25	20	150
	EXPECTED	54.0	14.1	44.2	20.7	16.9	
	DEVIATION	2.0	-5.1	-4.2	4.3	3.1	
	CELL CHI2	0.1	1.9	0.4	0.9	0.6	
	PERCENT	11.72	1.88	8.37	5.23	4.18	31.38
	ROW PCT	37.33	6.00	26.67	16.67	13.33	
	COL PCT	32.56	20.00	28.37	37.88	37.04	
TOTAL		172	45	141	66	54	478
		35.98	9.41	29.50	13.81	11.30	100.00

CHI-SQUARE = 5.508
DF = 4
PROB = 0.2390

respondents who answered question 11 incorrectly. The probability levels of 0.4129 and 0.6889 respectively indicate that there probably is no correlation between education level and the correctness of an answer to question 20 when these two groups of respondents are considered separately.

Table 23. Contingency table: response to question 20 versus family income

RESPONSE TO QUESTION 20	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	FAMILY INCOME LEVEL A	B	C	D	E	F	TOTAL
A	FREQUENCY	31	72	98	65	30	31	327
	EXPECTED	31.6	76.3	87.9	64.6	33.0	33.7	
	DEVIATION	-0.6	-4.3	10.1	0.4	-3.0	-2.7	
	CELL CHI2	0.0	0.2	1.2	0.0	0.3	0.2	
	PERCENT	6.51	15.13	20.59	13.66	6.30	6.51	68.70
	ROW PCT	9.48	22.02	29.97	19.88	9.17	9.48	
	COL PCT	67.39	64.86	76.56	69.15	62.50	63.27	
B	FREQUENCY	15	39	30	29	18	18	149
	EXPECTED	14.4	34.7	40.1	29.4	15.0	15.3	
	DEVIATION	0.6	4.3	-10.1	-0.4	3.0	2.7	
	CELL CHI2	0.0	0.5	2.5	0.0	0.6	0.5	
	PERCENT	3.15	8.19	6.30	6.09	3.78	3.78	31.30
	ROW PCT	10.07	26.17	20.13	19.46	12.08	12.08	
	COL PCT	32.61	35.14	23.44	30.85	37.50	36.73	
TOTAL		46	111	128	94	48	49	476
		9.66	23.32	26.89	19.75	10.08	10.29	100.00

CHI-SQUARE = 6.015
DF = 5
PROB = 0.3047

Table 24. Contingency table: response to question 20 versus education for all respondents

FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	EDUCATION LEVEL B	C	D	E	F	G	TOTAL
RESPONSE TO QUESTION 20 A	15 13.7 1.3 0.1 3.10 4.52 75.00	66 67.2 -1.2 0.0 13.64 19.88 67.35	106 98.8 7.2 0.5 21.90 31.93 73.61	23 19.9 3.1 0.5 4.75 6.93 79.31	87 88.5 -1.5 0.0 17.98 26.20 67.44	35 43.9 -8.9 1.8 7.23 10.54 54.69	332 68.60
B	5 6.3 -1.3 0.3 1.03 3.29 25.00	32 30.8 1.2 0.0 6.61 21.05 32.65	38 45.2 -7.2 1.2 7.85 25.00 26.39	6 9.1 -3.1 1.1 1.24 3.95 20.69	42 40.5 1.5 0.1 8.68 27.63 32.56	29 20.1 8.9 3.9 5.99 19.08 45.31	152 31.40
TOTAL	20 4.13	98 20.25	144 29.75	29 5.99	129 26.65	64 13.22	484 100.00

CHI-SQUARE = 9.505
DF = 5
PROB = 0.0905

Table 25. Contingency table: response to question 20 versus education for respondents answering question 11 correctly

EDUCATION LEVEL

RESPONSE TO QUESTION 20	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	B	C	D	E	F	G	TOTAL
A	FREQUENCY	3	26	46	10	38	20	143
	EXPECTED	3.6	28.0	40.2	8.1	38.2	24.9	
	DEVIATION	-0.6	-2.0	5.8	1.9	-0.2	-4.9	
	CELL CHI2	0.1	0.1	0.8	0.4	0.0	1.0	
	PERCENT	1.07	9.25	16.37	3.56	13.52	7.12	50.89
	ROW PCT	2.10	18.18	32.17	6.99	26.57	13.99	
	COL PCT	42.86	47.27	58.23	62.50	50.67	40.82	
B	FREQUENCY	4	29	33	6	37	29	138
	EXPECTED	3.4	27.0	38.8	7.9	36.8	24.1	
	DEVIATION	0.6	2.0	-5.8	-1.9	0.2	4.9	
	CELL CHI2	0.1	0.1	0.9	0.4	0.0	1.0	
	PERCENT	1.42	10.32	11.74	2.14	13.17	10.32	49.11
	ROW PCT	2.90	21.01	23.91	4.35	26.81	21.01	
	COL PCT	57.14	52.73	41.77	37.50	49.33	59.18	
TOTAL		7	55	79	16	75	49	281
		2.49	19.57	28.11	5.69	26.69	17.44	100.00

CHI-SQUARE = 5.025
DF = 5
PROB = 0.4129

Table 26. Contingency table: response to question 20 versus education for respondents answering question 11 incorrectly

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	EDUCATION LEVEL B	C	D	E	F	G	TOTAL
A		12	39	59	13	48	15	186
		12.2	38.3	59.8	12.2	49.5	14.0	
		-0.2	0.7	-0.8	0.8	-1.5	1.0	
		0.0	0.0	0.0	0.1	0.0	0.1	
		6.03	19.60	29.65	6.53	24.12	7.54	93.47
		6.45	20.97	31.72	6.99	25.81	8.06	
		92.31	95.12	92.19	100.00	90.57	100.00	
B		1	2	5	0	5	0	13
		0.8	2.7	4.2	0.8	3.5	1.0	
		0.2	-0.7	0.8	-0.8	1.5	-1.0	
		0.0	0.2	0.2	0.8	0.7	1.0	
		0.50	1.01	2.51	0.00	2.51	0.00	6.53
		7.69	15.38	38.46	0.00	38.46	0.00	
		7.69	4.88	7.81	0.00	9.43	0.00	
TOTAL		13	41	64	13	53	15	199
		6.53	20.60	32.16	6.53	26.63	7.54	100.00

CHI-SQUARE = 3.072
DF = 5
PROB = 0.6889

For the data in Table 27, the education classes used previously have been collapsed into two classes, respondents with some college and those with no college education. The probability value indicated is significant; the two variables are probably independent since the probability that the distribution shown is a chance occurrence is only 0.0377.

An even higher level of significance is indicated when the level of education is collapsed further with respondents having some graduate education in one class and all others in another class. As displayed in Table 28, the probability that the distribution of responses shown is a chance occurrence is only 0.0101, indicating that the variables are probably not independent. It is not clear, however, that these results suggest a significant relationship between education level and the correctness of the response to question 20. Although those with higher levels of education, particularly those with graduate education, appear to be more likely to answer question 20 correctly, this apparent correlation disappears when analyzing the data subsets for correct and incorrect responses to question 11.

Distribution site

The questionnaire distribution site codes used in Table 29 are the same as those presented in Table 2. The results in the table are somewhat difficult to interpret, due to the probability value being so near to five percent. It could be said that, because the value given, 0.0550, is greater than five percent, that the variables should be

TABLE 27. Contingency table: response to question 20 versus education collapsed into two classes -- college, and high school or less

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	EDUCATION COLLEGE	 HIGH SCHOOL OR LESS	TOTAL
	A	122 132.4 -10.4 0.8 25.21 36.75 63.21	210 199.6 10.4 0.5 43.39 63.25 72.16	332 68.60
	B	71 60.6 10.4 1.8 14.67 46.71 36.79	81 91.4 -10.4 1.2 16.74 53.29 27.84	152 31.40
	TOTAL	193 39.88	291 60.12	484 100.00

CHI-SQUARE = 4.317
DF = 1
PROB = 0.0377

considered independent, but the value is so close that a closer scrutiny of the table is in order. Of the chi-square value of 13.794, over half is due to the deviations from the "F" site, that is, Fort Dodge. Further study of responses from Fort Dodge seemed appropriate.

TABLE 28. Contingency table: response to question 20 versus education collapsed into two classes -- graduate school, and bachelor's or less

RESPONSE TO QUESTION 20	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	EDUCATION GRAD SCHOOL	 BACHELOR'S OR LESS	 TOTAL
	A	35 43.9 -8.9 1.8 7.23 10.54 54.69	297 288.1 8.9 0.3 61.36 89.46 70.71	332 68.60
	B	29 20.1 8.9 3.9 5.99 19.08 45.31	123 131.9 -8.9 0.6 25.41 80.92 29.29	152 31.40
	TOTAL	64 13.22	420 86.78	484 100.00

CHI-SQUARE = 6.622
DF = 1
PROB = 0.0101

As seen in Table 30, the probability value for the analysis of the data subset for correct responses to question 11 therein represented is further from a meaningful level of significance; however, the Fort Dodge contribution to the chi-square statistic is still higher than that for the other sites.

Table 29. Contingency table: response to question 20 versus questionnaire distribution site for all respondents

QUESTIONNAIRE DISTRIBUTION SITE

RESPONSE TO QUESTION 20	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	A	D	F	M	Q	S	T	W	TOTAL
A	FREQUENCY	28	87	24	33	31	68	25	41	337
	EXPECTED	28.8	89.0	32.9	34.2	32.2	62.3	21.2	36.3	
	DEVIATION	-0.8	-2.0	-8.9	-1.2	-1.2	5.7	3.8	4.7	
	CELL CHI2	0.0	0.0	2.4	0.0	0.0	0.5	0.7	0.6	
	PERCENT	5.69	17.68	4.88	6.71	6.30	13.82	5.08	8.33	68.50
	ROW PCT	8.31	25.82	7.12	9.79	9.20	20.18	7.42	12.17	
	COL PCT	66.67	66.92	50.00	66.00	65.96	74.73	80.65	77.36	
B	FREQUENCY	14	43	24	17	16	23	6	12	155
	EXPECTED	13.2	41.0	15.1	15.8	14.8	28.7	9.8	16.7	
	DEVIATION	0.8	2.0	8.9	1.2	1.2	-5.7	-3.8	-4.7	
	CELL CHI2	0.0	0.1	5.2	0.1	0.1	1.1	1.5	1.3	
	PERCENT	2.85	8.74	4.88	3.46	3.25	4.67	1.22	2.44	31.50
	ROW PCT	9.03	27.74	15.48	10.97	10.32	14.84	3.87	7.74	
	COL PCT	33.33	33.08	50.00	34.00	34.04	25.27	19.35	22.64	
TOTAL		42	130	48	50	47	91	31	53	492
		8.54	26.42	9.76	10.16	9.55	18.50	6.30	10.77	100.00

CHI-SQUARE = 13.794
DF = 7
PROB = 0.0550

Table 30. Contingency table: response to question 20 versus questionnaire distribution site for respondents answering question 11 correctly

FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	QUESTIONNAIRE DISTRIBUTION SITE A	D	F	M	Q	S	T	W	TOTAL
RESPONSE TO QUESTION 20 A	12 12.2 -0.2 0.0 4.20 8.28 50.00	33 36.5 -3.5 0.3 11.54 22.76 45.83	11 16.7 -5.7 2.0 3.85 7.59 33.33	17 17.2 -0.2 0.0 5.94 11.72 50.00	8 9.6 -1.6 0.3 2.80 5.52 42.11	36 29.4 6.6 1.5 12.59 24.83 62.07	12 9.1 2.9 0.9 4.20 8.28 66.67	16 14.2 1.8 0.2 5.59 11.03 57.14	145 50.70
RESPONSE TO QUESTION 20 B	12 11.8 0.2 0.0 4.20 8.51 50.00	39 35.5 3.5 0.3 13.64 27.66 54.17	22 16.3 5.7 2.0 7.69 15.60 66.67	17 16.8 0.2 0.0 5.94 12.06 50.00	11 9.4 1.6 0.3 3.85 7.80 57.89	22 28.6 -6.6 1.5 7.69 15.60 37.93	6 8.9 -2.9 0.9 2.10 4.26 33.33	12 13.8 -1.8 0.2 4.20 8.51 42.86	141 49.30
TOTAL	24 8.39	72 25.17	33 11.54	34 11.89	19 6.64	58 20.28	18 6.29	28 9.79	286 100.00

CHI-SQUARE = 10.537
DF = 7
PROB = 0.1601

The data subset for responses to question 20 from respondents who answered question 11 incorrectly is displayed in Table 31, broken down by distribution site. As indicated, the probability of this distribution occurring by chance is 0.0565. However, because the cells in the second row of the table have such low expected values, the chi-square test may not be meaningful. Further, the largest contribution to the chi-square value is in the second row of the site "Q", or Dubuque, responses, but these expected values are so low that no particular significance may be attached to this result.

Fort Dodge distribution site

It was noted previously that the test for independence of questionnaire distribution site and response to question 20 resulted in a probability value of 0.0550, with Fort Dodge responses making the greatest contribution to the chi-square total. In Table 32, the same analysis is performed, except that the Fort Dodge responses have been omitted completely. The resulting probability value, 0.4739, indicates that the distribution of responses shown is likely a chance occurrence and these variables are probably independent when Fort Dodge responses are excluded.

In Table 33, the analysis of the independence of site and response to question 20 is performed again, with the sites collapsed into two classes: Fort Dodge, and other. The probability value given, 0.0037, indicates that the distribution of responses shown is not likely to occur by chance and the variables are probably not independent.

Table 31. Contingency table: response to question 20 versus questionnaire distribution site for respondents answering question 11 incorrectly

FREQUENCY
EXPECTED
DEVIATION
CELL CHI2
PERCENT
ROW PCT
COL PCT

RESPONSE TO QUESTION 20		QUESTIONNAIRE DISTRIBUTE SITE: A	D	F	M	Q	S	T	W	TOTAL
A	FREQUENCY	16	53	13	16	23	31	13	24	189
	EXPECTED	16.8	53.3	14.0	15.0	26.2	29.0	12.2	22.5	
	DEVIATION	-0.8	-0.3	-1.0	1.0	-3.2	2.0	0.8	1.5	
	CELL CHI2	0.0	0.0	0.1	0.1	0.4	0.1	0.1	0.1	
	PERCENT	7.92	26.24	6.44	7.92	11.89	15.35	6.44	11.88	93.56
	ROW PCT	8.47	28.04	6.88	8.47	12.17	16.40	6.88	12.70	
	COL PCT	88.89	92.98	86.67	100.00	82.14	100.00	100.00	100.00	
B	FREQUENCY	2	4	2	0	5	0	0	0	13
	EXPECTED	1.2	3.7	1.0	1.0	1.8	2.0	0.8	1.5	
	DEVIATION	0.8	0.3	1.0	-1.0	3.2	-2.0	-0.8	-1.5	
	CELL CHI2	0.6	0.0	1.1	1.0	5.7	2.0	0.8	1.5	
	PERCENT	0.99	1.98	0.99	0.00	2.48	0.00	0.00	0.00	6.44
	ROW PCT	15.38	30.77	15.38	0.00	38.46	0.00	0.00	0.00	
	COL PCT	11.11	7.02	13.33	0.00	17.86	0.00	0.00	0.00	
TOTAL		18	57	15	16	28	31	13	24	202
		8.91	28.22	7.43	7.92	13.86	15.35	6.44	11.88	100.00

CHI-SQUARE = 13.714
DF = 7
PROB = 0.0565

Table 32. Contingency table: response to question 20 versus questionnaire distribution site, omitting Fort Dodge responses

RESPONSE TO QUESTION 20	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	QUESTIONNAIRE DISTRIBUTION SITE: A	D	M	Q	S	T	W	TOTAL
A	FREQUENCY	28	87	33	31	68	25	41	313
	EXPECTED	29.6	91.6	35.2	33.1	64.2	21.9	37.4	
	DEVIATION	-1.6	-4.6	-2.2	-2.1	3.8	3.1	3.6	
	CELL CHI2	0.1	0.2	0.1	0.1	0.2	0.5	0.4	
	PERCENT	6.31	19.59	7.43	6.98	15.32	5.63	9.23	70.50
	ROW PCT	8.95	27.80	10.54	9.90	21.73	7.99	13.10	
	COL PCT	66.67	66.92	66.00	65.96	74.73	80.65	77.36	
B	FREQUENCY	14	43	17	16	23	6	12	131
	EXPECTED	12.4	38.4	14.8	13.9	26.8	9.1	15.6	
	DEVIATION	1.6	4.6	2.2	2.1	-3.8	-3.1	-3.6	
	CELL CHI2	0.2	0.6	0.3	0.3	0.6	1.1	0.8	
	PERCENT	3.15	9.68	3.83	3.60	5.18	1.35	2.70	29.50
	ROW PCT	10.69	32.82	12.98	12.21	17.56	4.58	9.16	
	COL PCT	33.33	33.08	34.00	34.04	25.27	19.35	22.64	
TOTAL		42	130	50	47	91	31	53	444
		9.46	29.28	11.26	10.59	20.50	6.98	11.94	100.00

CHI-SQUARE = 5.563
DF = 6
PROB = 0.4739

Apparently, something about the Fort Dodge responses is different from those from other sites. However, before concluding that Fort Dodge respondents better understand traffic laws than those from other sites, further comparative analyses should be performed with regard to the other variables in the study and their relationship to questionnaire distribution site.

TABLE 33. Contingency table: response to question 20 versus questionnaire distribution site collapsed into two classes

	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	SITE		
		FORT DODGE	OTHER	TOTAL
RESPONSE TO QUESTION 20	A	24 32.9 -8.9 2.4 4.88 7.12 50.00	313 304.1 8.9 0.3 63.62 92.88 70.50	337 68.50
	B	24 15.1 8.9 5.2 4.88 15.48 50.00	131 139.9 -8.9 0.6 26.63 84.52 29.50	155 31.50
	TOTAL	48 9.76	444 90.24	492 100.00

CHI-SQUARE = 8.432
DF = 1
PROB = 0.0037

The main data set was partitioned into subsets for Fort Dodge and other questionnaire distribution sites. Analyses were then performed to determine if the tests of independence of response to question 20 and the socio-economic and driving experience variables were the same or different for these two data subsets. The only variable that gave differing results for the two data subsets was residential area type. Again, the classes of residential area used in the analysis were those previously reported in Figure 10. For the Fort Dodge data subset, the probability value of 0.0376 from Table 34 appears to indicate that response to question 20 and residential area type are probably not independent; however, the cells of the table have such low expected values the results are difficult to interpret. For the non-Fort Dodge subset of the data, the probability that the distribution in Table 35 is a chance occurrence, 0.6014, indicates that the variables are probably independent.

Several tests of independence gave probability values indicating the likely existence of a relationship at the five percent level of significance or better for both Fort Dodge and non-Fort Dodge data subsets. These included response to question 20 versus all of the following: years of driving experience, age, years since driver education, and whether driver education was taken. A similar result was obtained for tests of age versus whether driver education was taken.

Other tests of independence gave probability values indicating the failure to determine the existence of a relationship at any meaningful

Table 34. Contingency table: response to question 20 versus residential area type for Fort Dodge respondents only

FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	RESIDENTIAL AREA TYPE A	B	C	D	E	TOTAL
RESPONSE TO QUESTION 20 A	5 4.6 0.4 0.0 10.64 20.83 55.56	2 1.0 1.0 0.9 4.26 8.33 100.00	10 8.2 1.8 0.4 21.28 41.67 62.50	0 3.6 -3.6 3.6 0.00 0.00 0.00	7 6.6 0.4 0.0 14.89 29.17 53.85	24 51.06
B	4 4.4 -0.4 0.0 8.51 17.39 44.44	0 1.0 -1.0 1.0 0.00 0.00 0.00	6 7.8 -1.8 0.4 12.77 26.09 37.50	7 3.4 3.6 3.7 14.89 30.43 100.00	6 6.4 -0.4 0.0 12.77 26.09 46.15	23 48.94
TOTAL	9 19.15	2 4.26	16 34.04	7 14.89	13 27.66	47 100.00

CHI-SQUARE = 10.171
DF = 4
PROB = 0.0376

Table 35. Contingency table: response to question 20 versus residential area type for all except Fort Dodge respondents

RESPONSE TO QUESTION 20	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	RESIDENTIAL AREA TYPE A	B	C	D	E	TOTAL
A	FREQUENCY	111	34	91	41	27	304
	EXPECTED	115.0	30.3	88.2	41.6	28.9	
	DEVIATION	-4.0	3.7	2.8	-0.6	-1.9	
	CELL CHI2	0.1	0.4	0.1	0.0	0.1	
	PERCENT	25.75	7.89	21.11	9.51	6.26	70.53
	ROW PCT	36.51	11.18	29.93	13.49	8.88	
	COL PCT	68.10	79.07	72.80	69.49	65.85	
B	FREQUENCY	52	9	34	18	14	127
	EXPECTED	48.0	12.7	36.8	17.4	12.1	
	DEVIATION	4.0	-3.7	-2.8	0.6	1.9	
	CELL CHI2	0.3	1.1	0.2	0.0	0.3	
	PERCENT	12.06	2.09	7.89	4.18	3.25	29.47
	ROW PCT	40.94	7.09	26.77	14.17	11.02	
	COL PCT	31.90	20.93	27.20	30.51	34.15	
TOTAL		163	43	125	59	41	431
		37.82	9.98	29.00	13.69	9.51	100.00

CHI-SQUARE = 2.745
DF = 4
PROB = 0.6014

level of significance for both Fort Dodge and non-Fort Dodge data subsets. These included response to question 20 versus all of the following: time the questionnaire was held before mailing, percent gravel road driving, family income, education level, whether the driver's license had been revoked or suspended, annual driving mileage, and whether the driver had been involved in a motor vehicle accident in the past two years.

Further analyses

Some study variables have been noted as being significant in some respect, and were therefore selected for additional study. In one such follow-up, ages were separated into 18 classes, with the intent of achieving approximately the same number of responses in each class. The inclusive endpoints on the 18 classes selected were as follows: 16-18, 19-20, 21-22, 23-24, 25-26, 27-28, 29-30, 31-33, 34-36, 37-39, 40-42, 43-45, 46-50, 51-55, 56-60, 61-65, 66-70, and 71-80. A test of independence for these age classes versus response to question 20 resulted in a chi-square value of 60.525 with 17 degrees of freedom and a probability value of 0.0001. Thus, this additional test confirmed similar results noted previously from tests using fewer age classes. One interesting note that resulted from this test that was not apparent from earlier analyses was the tendency to find more missing values for the response to question 20 at higher ages. This may have been due to a shortcoming of the questionnaire. After the question: "Which vehicle has the right-of-way?" on the questionnaire, two choices were made available to the respondent. The letters A and B were placed after the question, on the same line. Perhaps the instruction "circle one" placed in parentheses following these letter choices would have made higher age drivers more cognizant of what was expected, and resulted in a higher percentage of responses for this question.

Another follow-up analysis of note involved the relationship of driver education and response to question 20. It was previously noted that, while there appeared to be a negative impact from driver education on a driver's ability to correctly identify the vehicle having the right-of-way in question 20, as shown in Figure 3, this impact may be explained by the relationship between driver education and age. A series of three tests was performed to further determine if that was indeed the case.

In the first test, age was classified into groups A, B, and C having the following inclusive endpoints, respectively: 16-30, 31-50, and 51-80. The main data set was then partitioned according to age class, and tests of independence for response to question 20 versus whether driver education had been taken were performed on each data subset. In no case was a probability value obtained that would indicate the likely existence of a relationship for any meaningful level of significance.

The second test was much like the first. Four age classes were used: 16-25, 26-35, 36-50, and 51-80. The main data set was again partitioned, and again the tests of independence were conducted for each data subset. Again, no probability values were obtained that would indicate the likely existence of a relationship for any meaningful level of significance.

To be sure that the arrangement of age classes was not affecting the results of the tests of independence, the third test was again like the first two, except that it used five classes of age. These were: 16-24, 25-29, 30-39, 40-54, and 55-80. Again the data set partitioning was performed and again the tests of independence were performed. The test of independence for response to question 20 versus whether driver education was taken resulted in a probability value of 0.0878 for the 40-54 year age class. No other probability values were obtained that would indicate the likely existence of a relationship for any meaningful level of significance. Because the 0.0878 value is of marginal significance, it is concluded that no measurable relationship between driver education and correct responses to question 20 can be determined from the questionnaire returns for this study.

Because age was found to be useful in determining whether driver education was significantly related to response to question 20, it was also used in a follow-up analysis of the differences between Fort Dodge and non-Fort Dodge questionnaire distribution sites. The five age classes used in Table 36 were defined as having the following inclusive endpoints: 16-24, 25-29, 30-39, 40-54, and 55-80. The probability value of 0.0670 given in the table is marginally significant, but does not necessarily indicate the existence of a relationship between site and age.

Table 36. Contingency table: questionnaire distribution site, collapsed into two classes, versus age, collapsed into five classes

SITE	FREQUENCY / EXPECTED / DEVIATION / CELL CHI2 / PERCENT / ROW PCT / COL PCT	AGE CLASSIFICATION A	B	C	D	E	TOTAL
FORT DODGE	FREQUENCY	5	7	17	9	13	51
	EXPECTED	11.5	8.2	11.0	9.9	10.3	
	DEVIATION	-6.5	-1.2	6.0	-0.9	2.7	
	CELL CHI2	3.7	0.2	3.3	0.1	0.7	
	PERCENT	0.97	1.36	3.31	1.75	2.53	9.92
	ROW PCT	9.80	13.73	33.33	17.65	25.49	
	COL PCT	4.31	8.43	15.32	9.00	12.50	
OTHER	FREQUENCY	111	76	94	91	91	463
	EXPECTED	104.5	74.8	100.0	90.1	93.7	
	DEVIATION	6.5	1.2	-6.0	0.9	-2.7	
	CELL CHI2	0.4	0.0	0.4	0.0	0.1	
	PERCENT	21.60	14.79	18.29	17.70	17.70	90.08
	ROW PCT	23.97	16.41	20.30	19.65	19.65	
	COL PCT	95.69	91.57	84.68	91.00	87.50	
TOTAL		116	83	111	100	104	514
		22.57	16.15	21.60	19.46	20.23	100.00

CHI-SQUARE = 8.774
DF = 4
PROB = 0.0670

There are some interesting observations that can be made from the table. Fort Dodge is over-represented in the 30-39 and 55-80 age groups. Fort Dodge is under-represented in the 16-24, 25-29 and 40-54 age groups. Most of the chi-square total of 8.774 is from the Fort Dodge cells for the 16-24 and 30-39 age groups. It should be noted that questionnaires were distributed at the Fort Dodge site on a warm, sunny, Monday in June, and all the questionnaires so distributed were distributed before 5:30 P.M. The time of day and day of the week, coupled with the weather, could account for the unusual age distribution for Fort Dodge respondents. Further, the age distribution could account for differences between Fort Dodge and other sites in the responses to question 20. It is concluded that there is not sufficient basis to establish that responses from Fort Dodge are inherently different from those at any other site in the study.

The four age classes used in Table 37 were defined with the inclusive endpoints: 16-25, 26-35, 36-50, and 51-80. This analysis added no new information to that reported above.

The three age classes used in Table 38 were defined with the inclusive endpoints: 16-30, 31-50, and 51-80. Again, no new information was added by this analysis.

In order better to define the relationship between age and response to question 20, a plot was constructed of the mean ages from the 18 age classes used in results previously reported versus the percentage of correct responses to question 20 in each of those classes. That plot is

TABLE 37. Contingency table: questionnaire distribution site, collapsed into two classes, versus age, collapsed into four classes

SITE	FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	AGE CLASSIFICATION A	B	C	D	TOTAL
SITE	FORT DODGE	7 13.5 -6.5 3.1 1.36 13.73 5.15	16 13.4 2.6 0.5 3.11 31.37 11.85	15 11.6 3.4 1.0 2.92 29.41 12.82	13 12.5 0.5 0.0 2.53 25.49 10.32	51 9.92
SITE	OTHER	129 122.5 6.5 0.3 25.10 27.86 94.85	119 121.6 -2.6 0.1 23.15 25.70 88.15	102 105.4 -3.4 0.1 19.84 22.03 87.18	113 113.5 -0.5 0.0 21.98 24.41 89.68	463 90.08
	TOTAL	136 26.46	135 26.26	117 22.76	126 24.51	514 100.00

CHI-SQUARE = 5.154
DF = 3
PROB = 0.1609

seen in Figure 17, and it is apparent that the percentage of correct responses to question 20 is likely to be some monotonically increasing function of age over the range of values indicated.

TABLE 38. Contingency table: questionnaire distribution site, collapsed into two classes, versus age, collapsed into three classes

FREQUENCY EXPECTED DEVIATION CELL CHI2 PERCENT ROW PCT COL PCT	AGE CLASSIFICATION A	B	C	TOTAL
SITE: FORT DODGE	14 21.0 -7.0 2.4 2.72 27.45 6.60	24 17.5 6.5 2.4 4.67 47.06 13.64	13 12.5 0.5 0.0 2.53 25.49 10.32	51 9.92
SITE: OTHER	198 191.0 7.0 0.3 38.52 42.76 93.40	152 158.5 -6.5 0.3 29.57 32.83 86.36	113 113.5 -0.5 0.0 21.98 24.41 89.68	463 90.08
TOTAL	212 41.25	176 34.24	126 24.51	514 100.00

CHI-SQUARE = 5.351
DF = 2
PROB = 0.0689

Worth further note is the increasing scatter of the points at the right hand end of the plot. This scatter occurs for two reasons. The variance of a proportion is given by pq/n, where p is the proportion of successes, q is 1-p and n is the sample size. One result of the numerator term is that variance is maximized where p = 0.5, and the

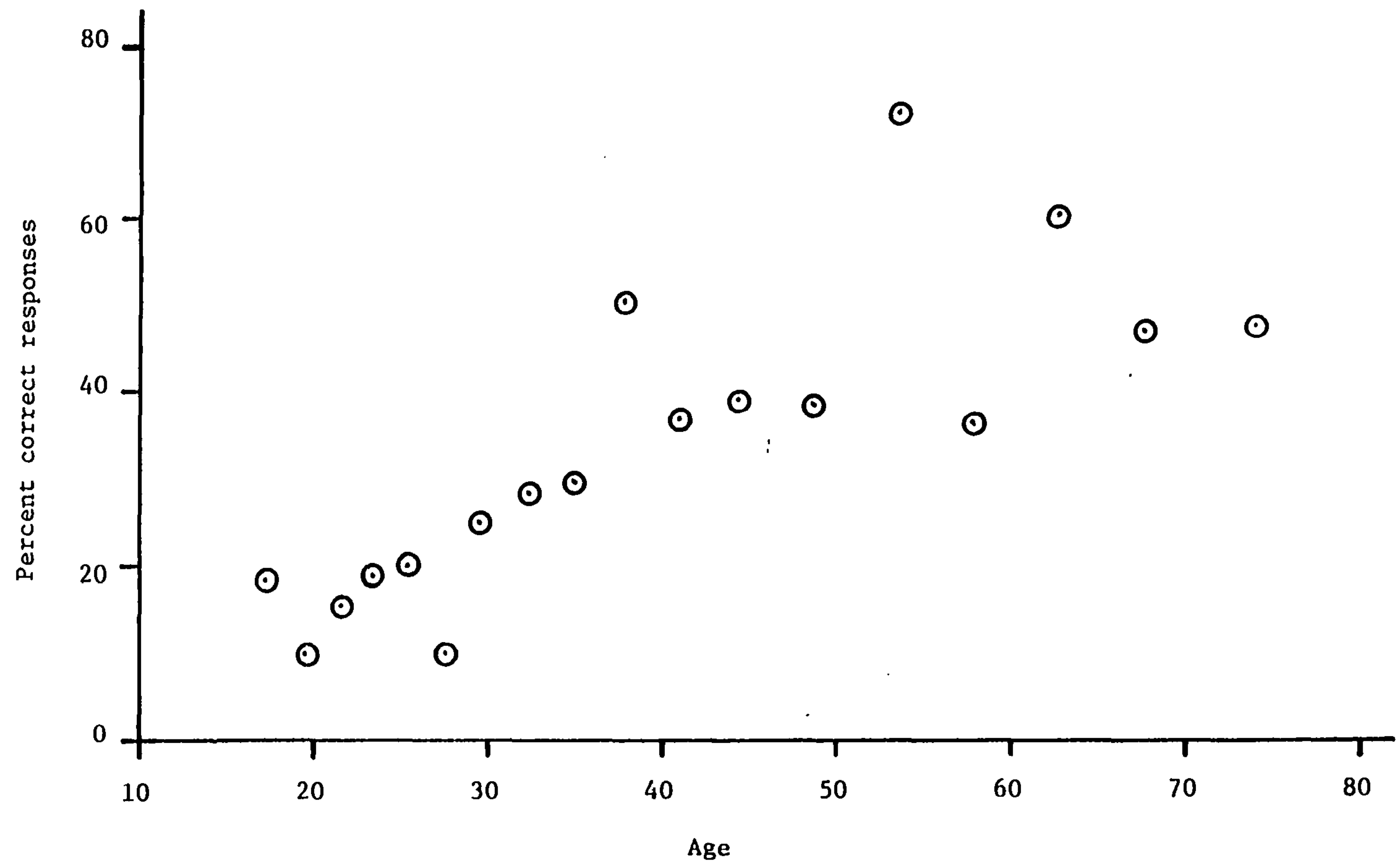


Figure 17. Scatter plot: percent correct responses to question 20 versus mean age of class

denominator term causes variance to decrease with increasing sample size. The first reason for the increasing scatter, then, is that the percentage of correct responses increases with increasing age, from between 10 and 20 percent to between 40 and 70 percent. These latter values are near the 50 percent value where variance is maximized. The second reason for the increasing scatter is the increasing number of missing values for responses to question 20 with increasing age, as noted previously. These missing values result in a smaller sample size, hence a larger variance.

An attempt was made to further define the relationship between age and percentage of correct responses to question 20. As a first step in generating and evaluating a set of alternative functions to be used to define this relationship, a set of weights was needed. In order to give the greatest weight to the points having the least variance in generating regression equations for the relationship between the variables, the weights assigned were the inverses of the variances calculated for the proportion of correct responses to question 20.

Figure 18 shows the linear function generated to fit the data. An analysis of variance (ANOVA) table generated in conjunction with the regression model reveals both satisfactory and unsatisfactory statistics for this model. The F test for the model is significant at the 0.0001 level, and the r-square value is 0.68. The t test for the parameters in the model reveals a significance level of 0.0001 for the coefficient, but the significance level of the intercept is 0.4822. Further, the standard error of estimate of the intercept is larger than the absolute value of the intercept.

Figure 19 shows the square root function generated to fit the data. An ANOVA table generated in conjunction with the regression model reveals generally satisfactory statistics for the model. The F test for the model is significant at the 0.0001 level, and the r-square value is 0.70. The t test for the parameters in the model reveals a significance level of 0.0001 for the coefficient and 0.0026 for the intercept. The standard error of estimate of the intercept is about 28 percent of the absolute value of the intercept.

Figure 20 shows the second order polynomial function generated to fit the data. An ANOVA table generated in conjunction with the regression model reveals both satisfactory and unsatisfactory statistics for the model. The F test for the model is significant at the 0.0001 level, and the r-square value is 0.73. The t test for the parameters in the model reveals a significance level of 0.1474 for the coefficient of the second order term, 0.0202 for the first order term, and 0.1109 for the intercept. Further, the standard errors are large compared with the estimates of the parameters in every case.

Figure 21 shows the logarithmic function generated to fit the data. An ANOVA table generated in conjunction with the regression model reveals generally satisfactory statistics for the model. The F test for the model is significant at the 0.0001 level, and the r-square value is 0.70. The t test for the parameters in the model reveals a significance

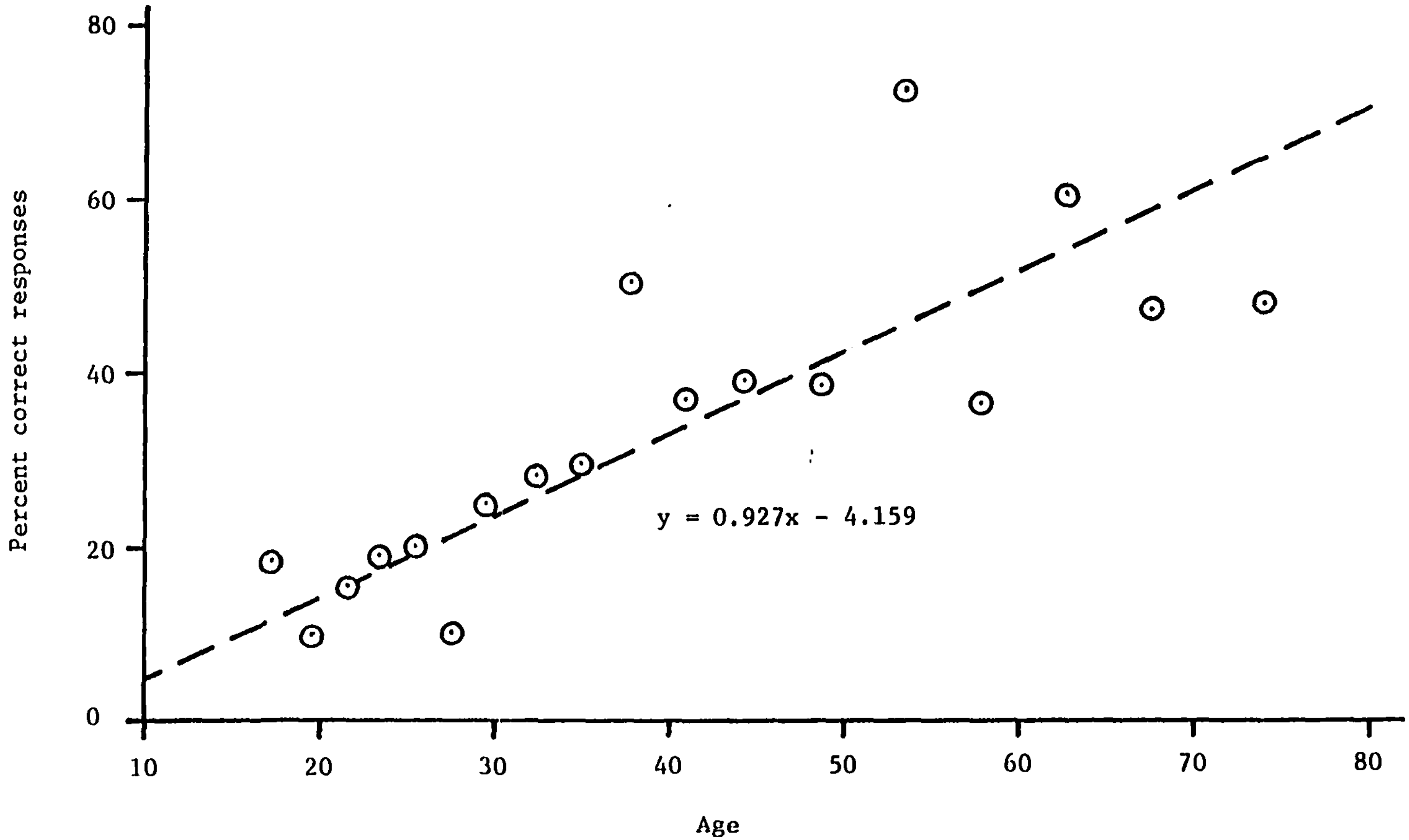


Figure 18. Weighted linear function: percent correct responses to question 20 versus mean age of class

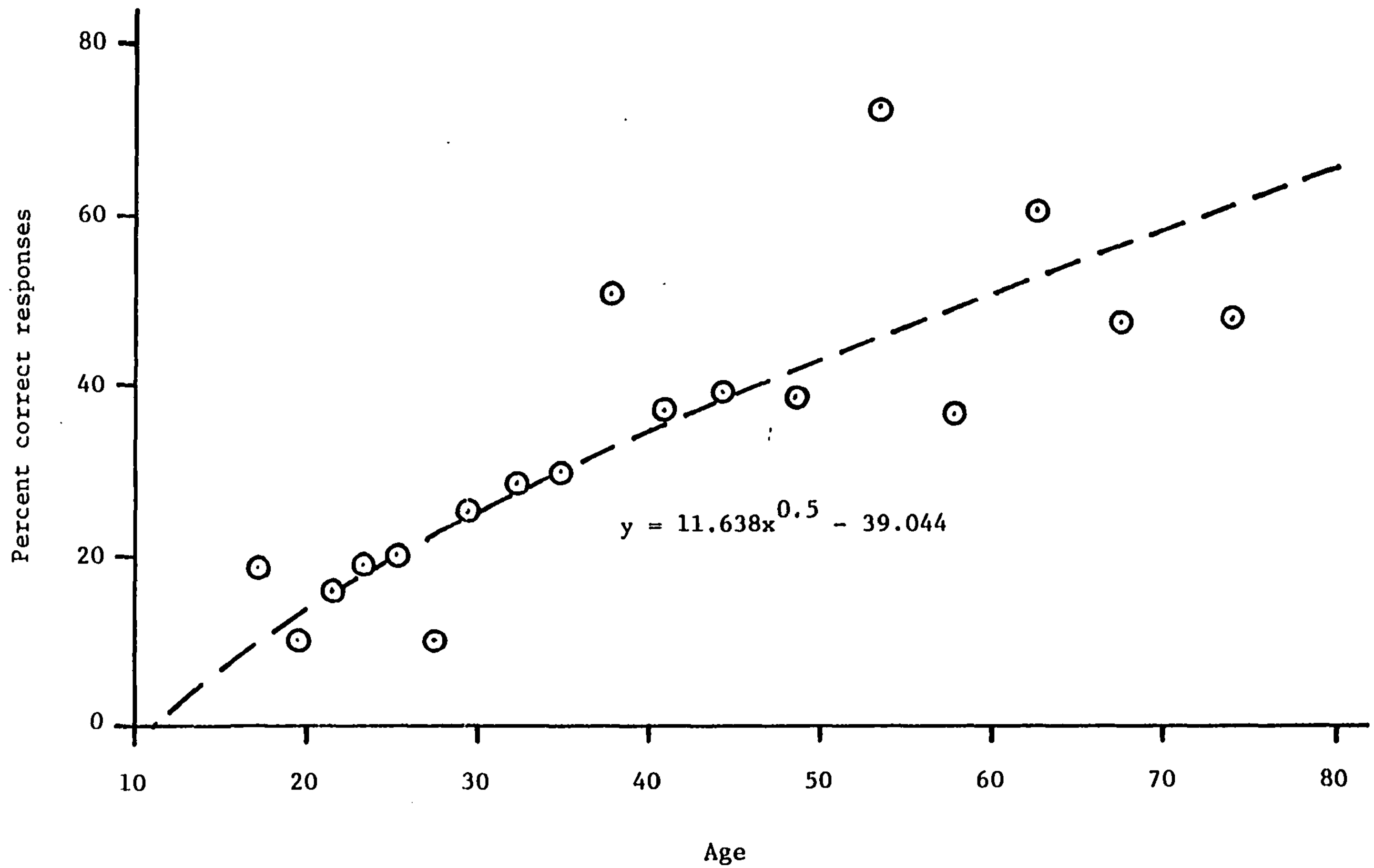


Figure 19. Weighted square root function: percent correct responses to question 20 versus mean age of class

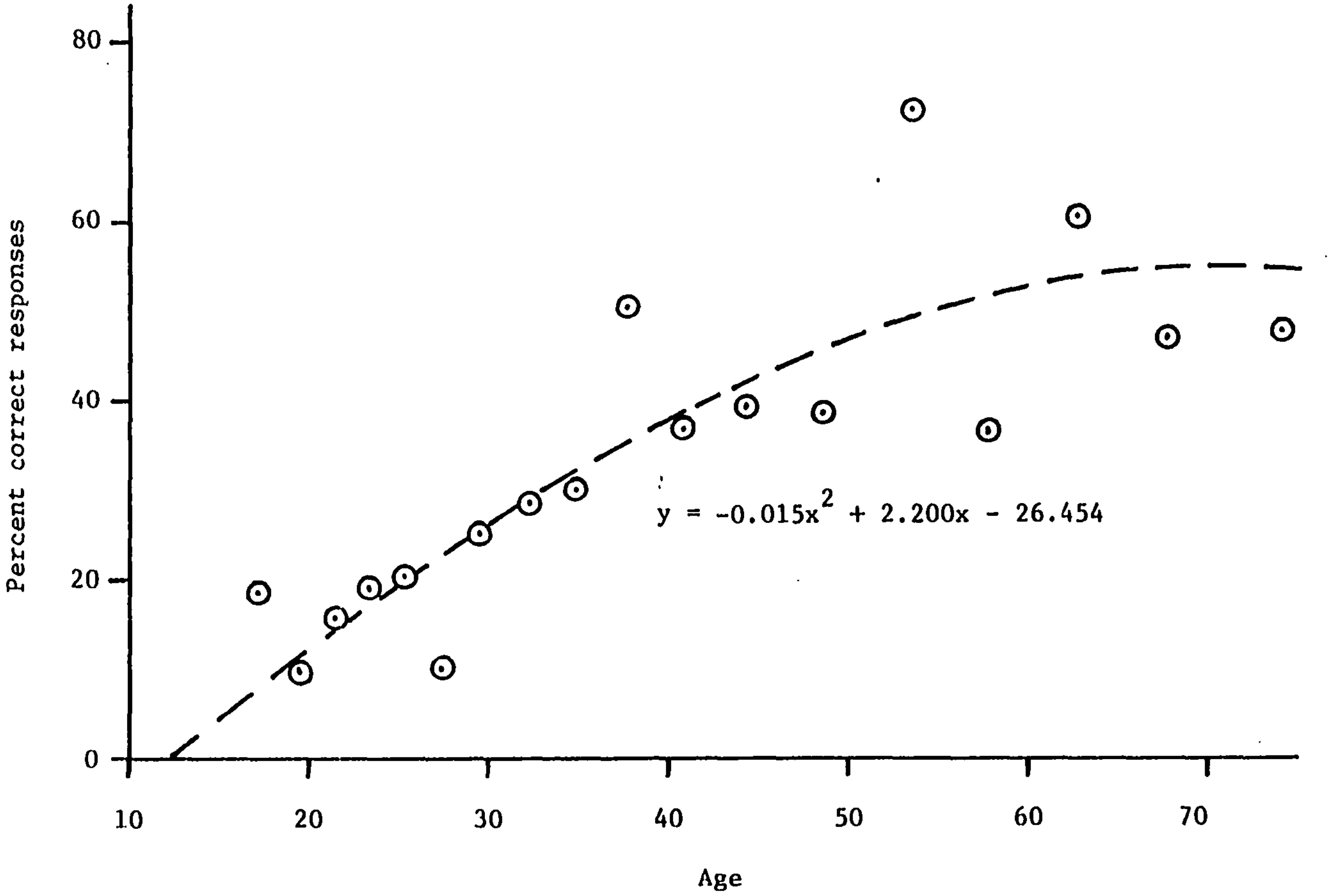


Figure 20. Weighted polynomial function: percent correct responses to question 20 versus mean age of class

level of 0.0001 for the coefficient and 0.0002 for the intercept. The standard errors are the smallest in comparison with the estimates of the model parameters of the four models generated.

It is concluded that the logarithmic function is the best of those studied for describing the relationship between age and response to question 20. That function should prove useful for comparison of this work with that of other investigators in the future.

Summary of Findings

Considering the entire sample of questionnaire respondents, 68.38 percent of the respondents incorrectly answered question 20 on the questionnaire, where question 20 asked which vehicle has the right-of-way in the situation depicted in Figure 3. Eliminating those responses from drivers incorrectly answering a question regarding the corresponding four-legged intersection driving situation, the percentage of respondents incorrectly answering question 20 was only reduced to 50.70 percent. The true values for the above percentages should lie within + or - 4.13 percent for the first, and + or - 5.79 percent for the second. These values are based on a 95 percent confidence level.

Age is the only variable related to the driver that was positively identified as having an impact on the driver's probability of correctly identifying the vehicle having the right-of-way at an uncontrolled T intersection in a situation like that depicted in Figure 3. No causal relationship was identified; only a functional relationship was

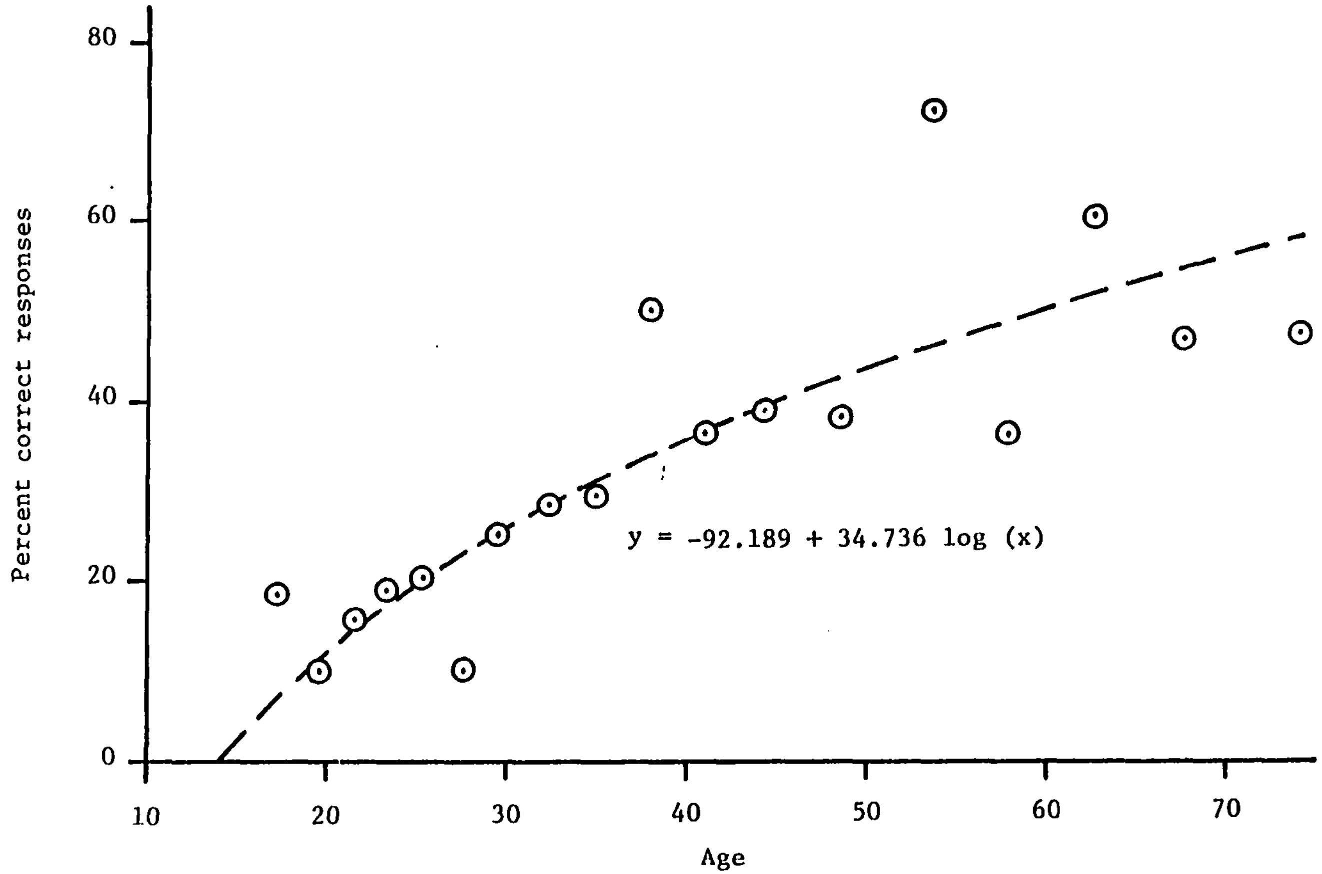


Figure 21. Weighted logarithmic function: percent correct responses to question 20 versus mean age of class

developed. Many variables related to the driver were determined to have no impact on the likelihood of the driver correctly identifying the vehicle having the right-of-way in the situation of interest. There were too many of these to repeat here; the interested reader is referred to the preceding material in this chapter.

ACCIDENT DATA STUDY

In order to evaluate the second and third hypotheses of this study, it was necessary to collect and analyze accident data for both uncontrolled T and uncontrolled four-legged intersections. Because of the low traffic volumes expected at such intersections, it was necessary to collect data for a large number of locations and for as long a time as possible so as to obtain a large enough number of accidents to provide statistically significant results to the analyses. The only data base known to this investigator with accident records available for a large number of locations in Iowa and kept over a long time was that maintained by the Iowa Department of Transportation.

Intersection Sample

The first step in selection of a sample of intersections for analysis was the random ordering of the counties in Iowa. Such a listing was obtained using a simple random numbers generator and the county numbers in common use. A letter was sent to the county engineer in each of the first five counties on this list requesting a county map showing the locations of either the controlled intersections or the uncontrolled intersections in the county, whichever proved to involve the least effort to prepare. A sample copy of the letter sent is contained in Appendix E.

It was estimated that information would be needed from approximately 15 counties to produce results of any meaningful significance. If it could be assumed that half of the county engineers contacted would respond with the information requested, 30 requests would be required to be sent. Two county engineers out of five responded to the initial mailing leading to the conclusion that the overall response would not be significantly different from 50 percent. This resulted in the mailing of 25 additional request letters to county engineers, with the counties selected in order from the randomized listing of counties mentioned previously. Another 14 county engineers responded to this request, giving a total of 16 responses to the 30 total letters sent. The locations of the counties that responded are shaded in the Iowa map given in Figure 22.

It was anticipated that the accident totals for a particular intersection type could depend on factors based on entering traffic volumes and on factors based on the number of intersections of each type in the sample; therefore, the number of intersections used from any particular county was the same for each type of intersection. Further, it was concluded that it would not be worthwhile to include a county in the sample if fewer than five uncontrolled intersections of either type were available for study in that county. Also, to avoid undue influence on the sample of any "hidden factors" associated with a county, no more than 25 intersections of each type were included in the sample from any county. The need for these measures was accented by the great variation in the numbers of uncontrolled intersections from one county to another. There were even large differences between the numbers of uncontrolled

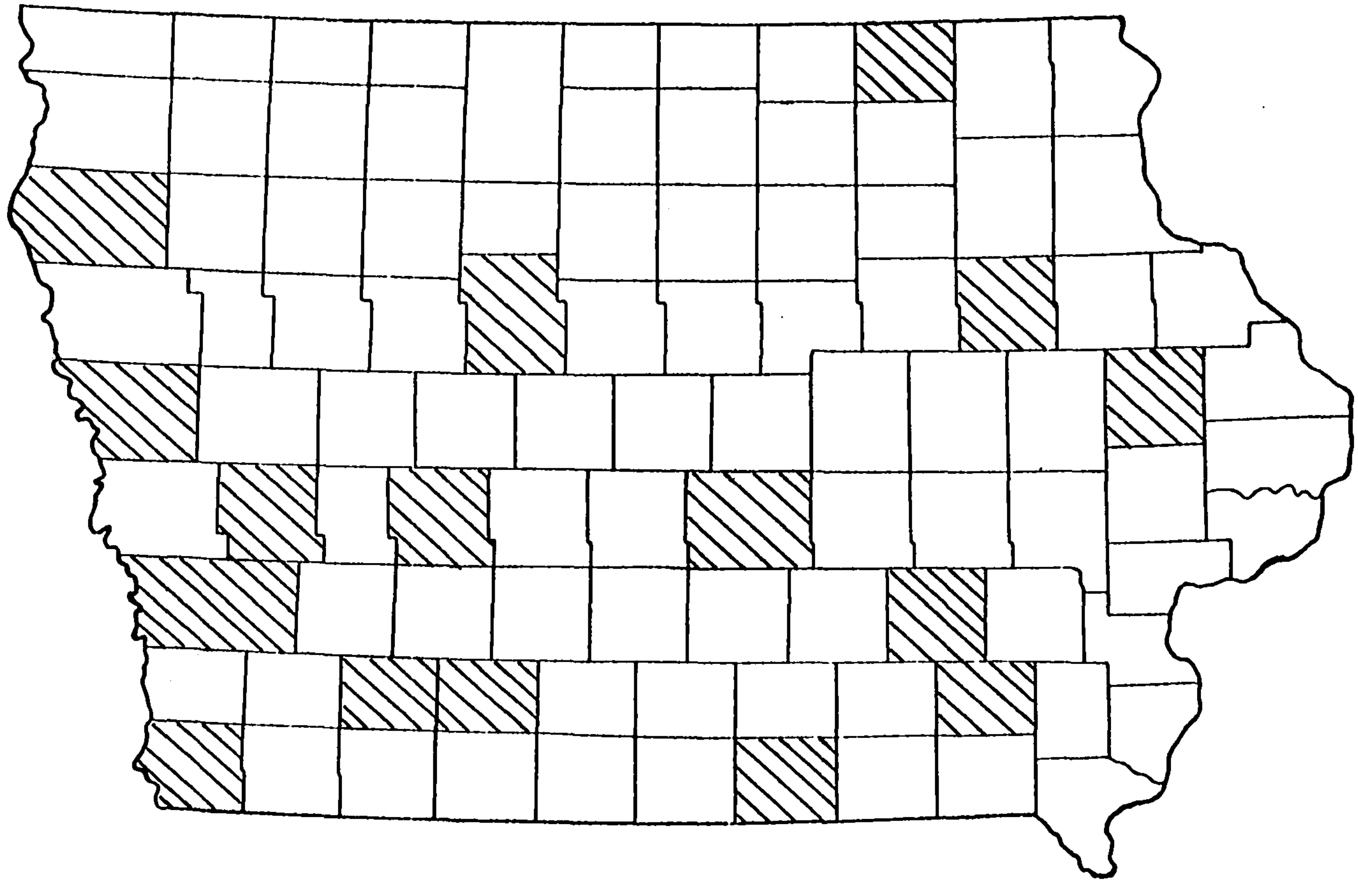


Figure 22. Counties returning information on uncontrolled intersection locations

intersections of the two intersection types within some counties. Figure 23 shows the locations in Iowa of the counties that were included in the study.

Other information needed with regard to the intersection sample included traffic volumes and node numbers for the intersections. Node maps were available in the Transportation Engineering section of the Iowa State University Civil Engineering Department. Traffic maps were obtained from the Iowa Department of Transportation for the first 30 counties on the randomized listing. The traffic maps used were those reflecting the latest available count data for a county, regardless of the year.

After receiving the information on controlled and uncontrolled intersections from the county engineers responding to the request, the intersections from each county to be included in the accident study were selected. It was decided not to include every uncontrolled intersection in the study. First, there were usually too many to include, based on the previously mentioned limit of 25 intersections of each type per county. Second, there were many intersections considered undesirable because of traffic volume, alignment, or other considerations that might unduly influence the tendency for those intersections to produce accidents. Following is a list of criteria used for rejecting intersections from the sample:

1. Intersection of a paved road with a gravel or unsurfaced road.
2. One of the intersecting roads on a county line.

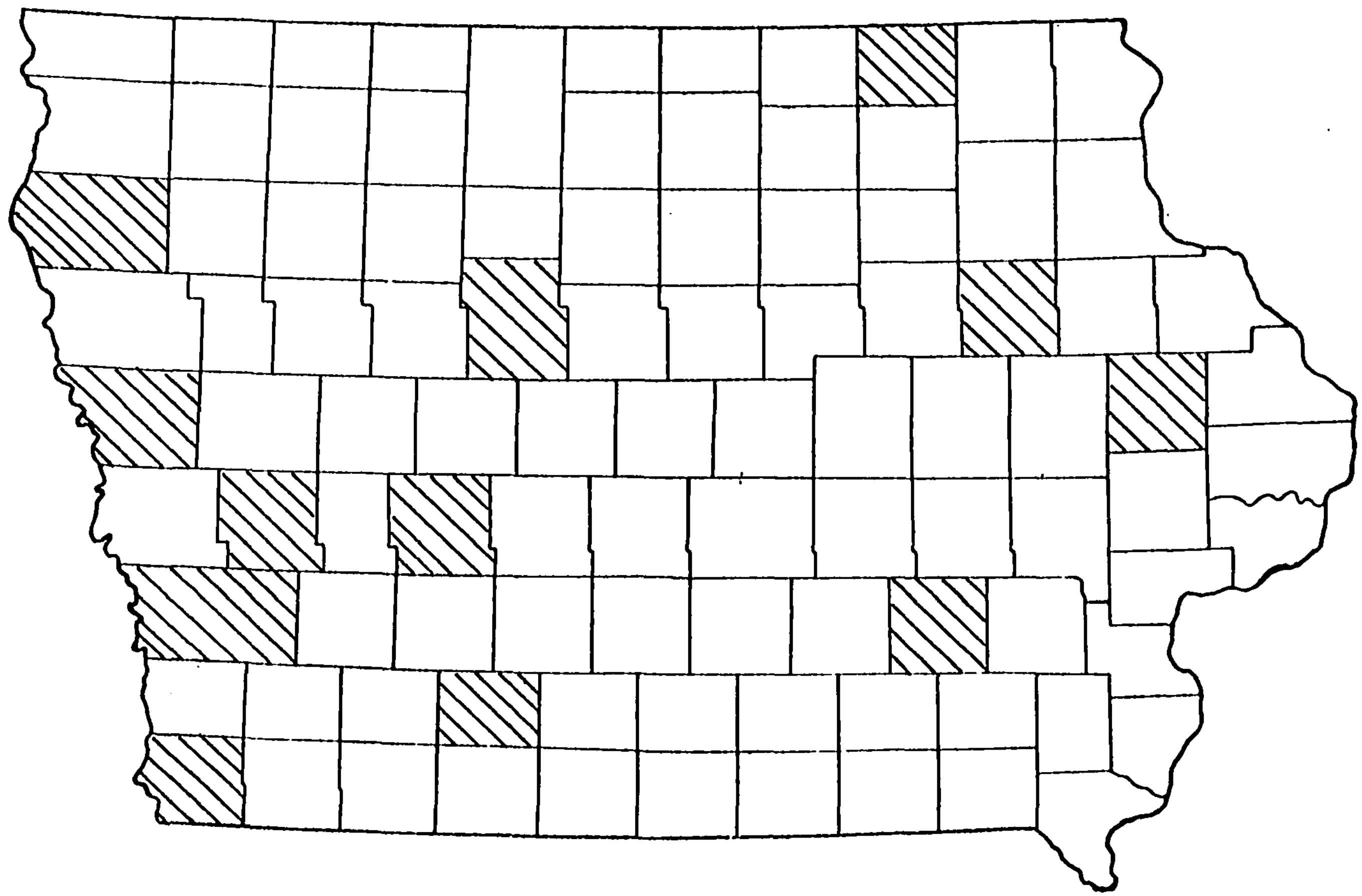


Figure 23. Counties used in study of accident data

3. Two T intersections within a quarter of a mile with stems off the same top.
4. Curved alignment leading into the intersection on one of the intersecting roads.
5. Skewed intersection.
6. T intersection with stem less than a quarter of a mile in length.
7. Grossly unbalanced traffic: any leg with over 75 percent of the entering traffic or any leg with less than five percent of the entering traffic (for the latter test, a leg with zero traffic volume was assumed to have an ADT volume of five).
8. Offset in a four-legged intersection.
9. Conflict in intersection type among the maps used in this study: maps from county engineers, traffic maps, and node maps.
10. Traffic volume information missing or unclear on the traffic map.
11. Intersection less than a quarter of a mile from a railroad crossing.
12. Possible confusion over jurisdiction.
13. Y configuration: cannot be separated into "stem" and "top" like a T intersection.

The first step in selecting the uncontrolled intersections to be included in the study was to number them. Separate numbering sequences were used for T and four-legged intersections. As the intersections were numbered, some so obviously met one or more of the above criteria that they were not assigned a number. The others were numbered using a repetitive, geographically back-and-forth system that was repeated for both intersection types, and was used for each county included in the sample.

As the next step in the selection process, a random list of the numbers from 1 to 200 was generated for each intersection type for each county in the sample. It was anticipated that no county in the sample would have more than 200 uncontrolled intersections of either type. The first 25 intersections whose numbers were found in the list for a particular intersection type in a given county were checked against the rejection criteria. If found to be suitable for inclusion in the sample, the intersection was listed separately with the applicable traffic information. This separate listing was continued until 25 suitable intersections were listed or until the list of available intersections was exhausted if fewer than 25 were available. If one type of intersection had fewer available than the other at the conclusion of this process, the longer list was shortened by removing the last entries until both lists were the same length.

At the conclusion of the above process for all the counties in the sample, node lists were generated using the maps with the assigned nodes for each intersection shown. These lists were sent to the Iowa Department of Transportation in letters requesting all accident information available for the nodes in the list from January 1, 1977 through the most current information available in the data base. A sample copy of one such letter is shown in Appendix F.

During this process, intersection rejection continued. Specifically, intersections were removed from the list when the intersection type on the node map disagreed with that shown on the other maps. Substitutions were made from the random number list if more intersections were still available.

The information from the county engineers on intersection control was not taken as being errorless. In four counties, all the sample intersections were field checked to determine if, in fact, they were uncontrolled. In addition, substitute intersections were checked in these counties in case the field check revealed a need to remove any intersections from the sample. A total of 219 intersections were checked, and only 10 were found to have control devices present. Four intersections were checked in other counties when accident reports for those intersections were found to mention STOP signs. Three of the four were found to have STOP signs present and were eliminated from the sample. It was decided that further field checking would accomplish little, considering the small percentage error rate for the intersections that were checked.

Analysis

The accident information from the Iowa Department of Transportation covered the time period from January 1, 1977 through September 30, 1984. After all the accident information was received, accident rates were calculated for each intersection type for each county in the sample. Table 39 gives the results of these calculations for four-legged intersections. The range of values of accident rates noted therein is interesting for the scatter demonstrated. Accident occurrences are random events, and the numbers listed plainly demonstrate this. The counties are not listed by name or in any logical order in the table because of the inherent unfairness of inferring, for example, that the county engineer in county E is doing a better job than the county engineer in county J solely on the basis of a lower accident rate at uncontrolled four-legged intersections.

Table 40, for T intersections, again shows a great deal of scatter in individual county accident statistics. However, the individual rates are generally lower than the corresponding rates for four-legged intersections. Though the counties are again listed in no logical order, they are listed in the same order as in Table 39 for convenience. Of greater interest from these tables are the overall rates for accidents at T and four-legged intersections.

The rates calculated from the intersection sample chosen are 0.733 accidents per million entering vehicles for four-legged intersections and 0.251 accidents per million entering vehicles for T intersections.

TABLE 39. Uncontrolled four-legged intersection accident rates over 7.75 years

County[a]	Number of four-legged intersections	Entering Volume (MEV)	Number of Accidents	Accident Rate (Acc/MEV)
A	22	4.2643	5	1.17
B	25	4.0380	3	0.74
C	23	3.3662	2	0.59
D	16	3.1116	0	0.00
E	22	4.6887	1	0.21
F	19	3.6505	3	0.82
G	25	5.5019	6	1.09
H	13	2.3507	3	1.28
J	16	2.0084	2	1.00
K	13	1.8599	1	0.54
L	25	3.8061	3	0.79
M	9	0.9052	0	0.00
TOTALS	228	39.5515	29	0.733

[a]Order scrambled intentionally.

On the surface, there appears to be an overwhelming difference in the rates, but this must be tested statistically in order to make a valid comparison.

In a 1967 paper on accident data analysis, Morin (23) presented equations for calculation of upper and lower "control limits" for accident rates. These equations were applied to the data in Tables 39 and 40 using a five percent probability of the true rates being equal to

TABLE 40. Uncontrolled T intersection accident rates over 7.75 years

County[a]	Number of T intersections	Entering Volume (MEV)	Number of Accidents	Accident Rate (Acc/MEV)
A	22	3.5359	0	0.00
B	25	4.1300	1	0.24
C	23	2.6661	1	0.38
D	16	2.6307	0	0.00
E	22	3.5572	2	0.56
F	19	2.5841	0	0.00
G	25	3.8259	0	0.00
H	13	1.7482	0	0.00
J	16	1.4582	2	1.37
K	13	2.2390	1	0.45
L	25	2.5784	1	0.39
M	9	0.8585	0	0.00
TOTALS	228	31.8122	8	0.251

[a]Order scrambled intentionally.

or outside the endpoints of the interval from the lower to the upper control limit. The resulting interval for T intersections was 0.061 to 0.441 accidents per million entering vehicles. For four-legged intersections the interval calculated was 0.584 to 0.882. The intervals do not overlap, so the rates could be said to be different at a significance level of five percent.

The Poisson distribution is generally used to model accident occurrence. Further analysis of the calculated accident rates incorporated this distribution, in which the mean and variance are equal. If the null hypothesis that there is no difference in the mean accident rates, versus the alternative hypothesis that the accident rate for four-legged intersections is larger than that for T intersections, is adopted for analysis, the test statistic is a Z statistic if we assume the variances to be known. The Z statistic thus calculated is 2.965, indicating that the mean accident rates are different at the 0.005 level of significance. The same result is obtained if the variances are unknown and the values from the Poisson assumption are taken to be merely sample variances. In this latter case, the test statistic is a T' statistic, but this results in no changes to the values calculated or obtained from appropriate statistical tables.

Evaluation of the third hypothesis made in the Introduction was intended, but the number of T intersection accidents obtained was too low for any meaningful analysis. There were eight T intersection accidents in the sample, and only one of these involved a vehicle approaching on the stem of the T colliding with a vehicle approaching from its left on the top of the T. This is too little information to be useful in formulating any conclusions regarding accident patterns.

Summary of Findings

The information provided by county engineers to this study revealed that there are hundreds of uncontrolled intersections in Iowa, but with a great deal of variability in frequency of occurrence from county to county. Further, the field checks of sample intersections revealed that Iowa's county engineers have an accurate picture of control device locations within their counties, with only 10 errors found in a check of 219 intersections.

T intersections were found to have an accident rate of 0.251 accidents per million entering vehicles. The rate for four-legged intersections was found to be 0.733. Statistical tests of the difference between these values proved significant. The lower to upper control limit intervals found for the rates were 0.061 to 0.441 for T intersections and 0.584 to 0.882 for four-legged intersections. The difference in mean rates was found to be significant at the 0.005 level. Evaluation of T intersection accident patterns was not carried out due to the small sample of only eight accidents.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Three hypotheses were made in the first chapter of this work. The first dealt with drivers' perception of right-of-way at uncontrolled T intersections, while the two others dealt with the accident producing tendencies of T intersections. In the following discussion, findings will be summarized as related to the stated hypotheses, then conclusions will be drawn from them.

Summary of Findings

Findings related to the first hypothesis

In the questionnaire survey of Iowa drivers, it was found that 68.38 percent of the drivers responding answered incorrectly when asked who had the right-of-way at an uncontrolled T intersection when the vehicle approaching from the stem of the T was to the right of the vehicle approaching across the top of the T. Those drivers also responding incorrectly to a control question in which a turning vehicle has the right-of-way at an uncontrolled four-legged intersection were "filtered out" of the sample, and the percentage answering the aforementioned T intersection question incorrectly was still 50.70 percent.

Confidence intervals were calculated for the above results, using a 95 percent confidence level. The confidence interval for the first value above was calculated to be 68.38 percent + or - 4.13 percent. The other confidence interval was 50.70 percent + or - 5.79 percent.

Age was determined to be related to the likelihood of a correct response to the T intersection question. No causal relationship was identified, but a statistically significant regression function was developed. No other socio-economic or driving experience variables were identified as being related to the likelihood of a correct response.

Findings related to the second hypothesis

Accident rates were calculated for both uncontrolled T and uncontrolled four-legged intersections using a sample of 228 intersections of each type. Accident data were obtained for a time period covering seven years and nine months from the Iowa Department of Transportation. The rates calculated were 0.733 accidents per million entering vehicles for four-legged intersections, and 0.251 accidents per million entering vehicles for T intersections.

Intervals based on upper and lower control limits were calculated for these rates using a 95 percent confidence level. The intervals so calculated were 0.584 to 0.882 accidents per million entering vehicles for four-legged intersections and 0.061 to 0.441 for T intersections. Further, the difference in the accident rates was tested and found to be statistically significant at the 0.005 level.

Findings related to the third hypothesis

The third hypothesis presented in the Introduction dealt with the types of accidents that might be expected to occur in disproportionately large numbers at uncontrolled T intersections. Unfortunately, the number of accidents in the sample of uncontrolled T intersections was so low, numbering only eight, that no analysis was feasible with regard to accident type.

Findings from the literature search

The literature search collected information that verified the existence of a perception among transportation professionals that T intersections are safer than four-legged intersections. An example of this is given in the quote from Traffic Control & Roadway Elements (5), repeated here from the second chapter of this work: "In addition, the findings ... tend to show that three-way intersections are inherently safer than four-way. This probably results from fewer points of possible conflict in three-way intersections ...."

A dissenting voice was heard from Rosenbaum (32) in the finding that: "Geometry (three-leg and four-leg) does not play a major role in either the safety or operation of low volume intersections." Rosenbaum was not alone. A paper by Lum and Parker (22) reported that "There is no relationship between the number of approaches on the minor roadway and accident experience for major volume under 1,000 vpd."

A significant finding in the literature was that eight states have enacted legislation giving the right-of-way at uncontrolled T intersections to the vehicle crossing the top of the T, regardless of the direction of travel. These eight states are Arizona, Connecticut, Georgia, Texas, California, Illinois, Maryland, and Nevada. Of further interest is the lack of any research to prompt the legislatures in those states to pass such legislation.

Conclusions and Recommendations

The hypothesis of a difference between right-of-way perception and legal right-of-way assignment at uncontrolled T intersections was verified by the findings of this study. The hypothesis of a higher accident rate at uncontrolled T intersections than at uncontrolled four-legged intersections was not confirmed by the findings of this study; in fact, the accident rate at uncontrolled T intersections was shown to be significantly lower than that for uncontrolled four-legged intersections. On this basis, the conclusions, presented above, of Rosenbaum (32) and of Lum and Parker (22) cannot be supported by the work represented herein. A conclusion that uncontrolled T intersections are safer than uncontrolled four-legged intersections is supported by this work.

Bunte (7) has indicated a need to stop traffic on the stem of the T intersection of "major roads." Smith (33) has termed the T intersection an "inconsistency." This work has identified a difference between right-of-way perception and legal right-of-way assignment at uncontrolled T intersections. Eight states now have special right-of-way rules for T intersections. Members of the legal profession cannot be expected to overlook any of these facts. The door is presently open for tort liability claims in certain accidents at uncontrolled T intersections.

Based on the findings herein, the State of Iowa should pass a law enacting a special T intersection right-of-way rule similar to those already in use in the eight states having such rules. This should be followed by a public education program of sufficient duration to assure coverage of virtually all licensed drivers in Iowa. Failure to pass such a law would leave open the door to tort liability claims at uncontrolled T intersections. Installation of STOP or YIELD signs on the stems of T intersections could be considered for the purpose of meeting driver expectancy, but would seriously burden the budgets of many counties. Further, the lower overall accident rate for uncontrolled T intersections as compared with uncontrolled four-legged intersections suggests there may not be much support among public officials for such a signing policy.

If a revised T intersection right-of-way rule is needed in Iowa, perhaps such a rule should be uniformly applied throughout the United States. Research is needed in other states having different terrain, different vegetation, different degrees of urbanization, and other different characteristics that may lead to different results than those presented herein. If such research is found to corroborate this work, the objective of uniformity in application of traffic laws suggests that the *Uniform Vehicle Code* should be appropriately modified to reflect those results.

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- Southern Hills Mall, Sioux City
- Kennedy Mall, Dubuque
- Willowbrook Plaza, Mason City
- Marshalltown Mall, Marshalltown

I would like to extend my thanks to the county engineers in Iowa. The information provided by those responding to my request was invaluable to this study. Dr. William F. Woodman of the ISU Sociology Department provided much assistance in the development of the questionnaire used in this study, for which I remain grateful. When I needed advice on matters related to statistical analysis, I was able to count on the willing assistance of Dr. Kenneth J. Koehler, who also served as a member of my Program of Study Committee. My thanks are extended to him, as well as to the other members of my Program of Study Committee, who provided occasional "sounding board" service when I needed to talk through an idea.

I would like to thank my major professor, Dr. R. L. Carstens, who gave support and encouragement throughout my studies, and who provided invaluable proofreading and editing of my work. My good friends Kevin and Joyce Wolka provided much support and assistance, particularly in preparation of tables and figures. To them I extend my deepest gratitude. Last of all, I would like to thank my wife, Jan, and my children, Robert, Jr., David, and Christina for their patience and understanding without which this work would not have been possible.

APPENDIX A: QUESTIONNAIRE

Robert E. Montgomery
Iowa State University
Department of Civil Engineering
Ames, Iowa 50011

Staple Here After Folding

Thank you for your help with my research. To help me assure the confidentiality of your responses, please do not place any information on this sheet that could identify you. For each question, please select the answer you feel to be the best of those offered.

The following group of questions is related to your background.

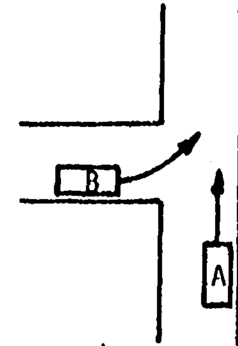
1. What is your age? _____ years
2. How would you describe the area where you live?
   [ ]a. urban area, in the city itself or near suburbs
   [ ]b. urban area, in outlying suburbs or surrounding towns
   [ ]c. smaller city, urban in character
   [ ]d. small town (under 2500 population)
   [ ]e. rural area
3. What is the level of your family's annual income? (All responses will be confidential.)
   [ ]a. less than $10,000 [ ]d. $30,000-$40,000
   [ ]b. $10,000-$20,000 [ ]e. $40,000-$50,000
   [ ]c. $20,000-$30,000 [ ]f. over $50,000
4. What is the highest level of education you have completed?
   [ ]a. less than 8th grade
   [ ]b. 8th grade thru some high school
   [ ]c. high school graduate
   [ ]d. some college (less than Bachelors degree)
   [ ]e. Associate degree
   [ ]f. Bachelors degree
   [ ]g. advanced or professional degree
5. At what age did you receive your drivers license? _____ years
6. Has your drivers license ever been revoked or suspended? yes no
7. Have you ever taken a driver education course? yes no
   If yes, how many years ago? _____ years
8. How many miles do you drive in an average year?
   [ ]a. less than 5000 [ ]d. 15,000-20,000
   [ ]b. 5000-10,000 [ ]e. 20,000-25,000
   [ ]c. 10,000-15,000 [ ]f. over 25,0000
9. What percent of your driving in the past year has been on gravel roads? _____%
10. Have you been involved (as a driver) in a motor vehicle accident in the past two (2) years? yes no

(over)

[ ]c. proceed without slowing (except as needed to make the turn)
[ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
[ ]e. other (explain) ______________________

17. Which vehicle has the right-of-way? A B

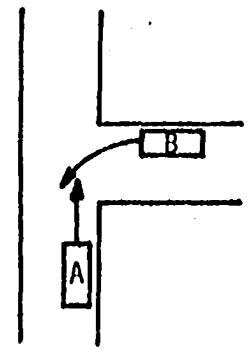
18. You are driving vehicle A. Should you:
[ ]a. yield right-of-way, stopping if necessary
[ ]b. slow down and proceed with caution
[ ]c. proceed without slowing
[ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
[ ]e. other (explain) ______________________



19. You are driving vehicle B. Should you:
[ ]a. yield right-of-way, stopping if necessary
[ ]b. slow down and proceed with caution
[ ]c. proceed without slowing (except as needed to make the turn)
[ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
[ ]e. other (explain) ______________________

20. Which vehicle has the right-of-way? A B

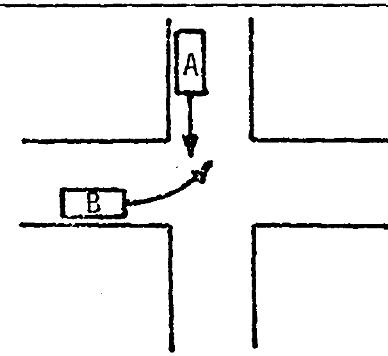
21. You are driving vehicle A. Should you:
[ ]a. yield right-of-way, stopping if necessary
[ ]b. slow down and proceed with caution
[ ]c. proceed without slowing
[ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
[ ]e. other (explain) ______________________



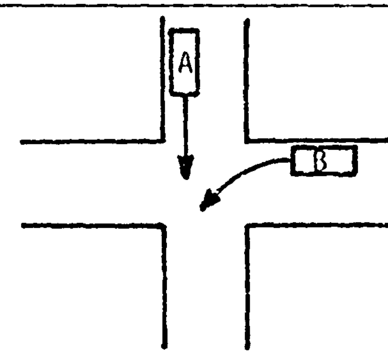
22. You are driving vehicle B. Should you:
[ ]a. yield right-of-way, stopping if necessary
[ ]b. slow down and proceed with caution
[ ]c. proceed without slowing (except as needed to make the turn)
[ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
[ ]e. other (explain) ______________________

Thank you for your time and effort. I sincerely appreciate your help.

The following group of questions is related to commonly-encountered driving situations. The questions will be presented in sets of three (3), with a sketch accompanying each set. The sketches show intersections with two (2) vehicles about to arrive. Assume that there are no traffic signals, stop signs or yield signs present. Also assume that the roads shown have gravel surfaces and are adequate in width for one (1) lane of travel in each direction. Assume the vehicles shown are passenger cars traveling so as to arrive at the intersection at approximately the same time.



11. Which vehicle has the right-of-way? A B
12. You are driving vehicle A. Should you:
    [ ]a. yield right-of-way, stopping if necessary
    [ ]b. slow down and proceed with caution
    [ ]c. proceed without slowing
    [ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
    [ ]e. other (explain) ____________________
13. You are driving vehicle B. Should you:
    [ ]a. yield right-of-way, stopping if necessary
    [ ]b. slow down and proceed with caution
    [ ]c. proceed without slowing (except as needed to make the turn)
    [ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
    [ ]e. other (explain) ____________________



14. Which vehicle has the right-of-way? A B
15. You are driving vehicle A. Should you:
    [ ]a. yield right-of-way, stopping if necessary
    [ ]b. slow down and proceed with caution
    [ ]c. proceed without slowing
    [ ]d. assume you have the right-of-way; proceed quickly through the intersection before the other vehicle
    [ ]e. other (explain) ____________________
16. You are driving vehicle B. Should you:
    [ ]a. yield right-of-way, stopping if necessary
    [ ]b. slow down and proceed with caution
    [ ]c. proceed without slowing (except as needed to make the turn)
    [ ]d. assume you have the right-of-way; proceed quickly

APPENDIX B: INFORMATION FOR QUESTIONNAIRE RESPONDENTS UNDER 18

APPENDIX C: SHOPPING MALL CORRESPONDENCE AND FORMS

APPLICATION FOR PERMIT TO USE COMMON AREA IN Valley West Mall SHOPPING CENTER

NAME OF ORGANIZATION *(Please Print)* Bob Montgomery 294-677

MAILING ADDRESS IA State U Dept. of Civil Eng

CITY Ames COUNTY IA (Story) STATE 50011

NAMES OF OFFICERS OR RESPONSIBLE OFFICIALS *(Please Print)*

1. ______ Title ______ Phone ______
2. ______ Title ______ Phone ______
3. ______ Title ______ Phone ______

If permit to use Common Area has been issued in past, give dates of last such permit: ______

IF MORE DETAIL IS NECESSARY TO COMPLETE THE FOLLOWING PLEASE PRINT OR TYPE DATA ON SEPARATE SHEETS OF PAPER AND ATTACH DATA SHEETS TO THIS APPLICATION FORM.

Days requested for use of Common Areas *(Designated area subject to availability at time requested)*:

______ Time From ______ M to ______ M

______ Time From ______ M to ______ M

Describe nature or type of intended use: ______

If use of signs, special decoration, displays or devices is requested, give details ______

Persons in charge during period of requested use *(Please Print)*:

Name ______ Date ______ Time From ______ M to ______ M

Name ______ Date ______ Time: From ______ M to ______ M

Name ______ Date ______ Time From ______ M to ______ M

Please locate your exhibit, display or equipment on the center's Common Area map attached.

(Please Read Carefully)

The undersigned hereby represents that he is the Applicant or an officer or other authorized agent of the Applicant named herein and that he is over 21 years of age. The undersigned further acknowledges he has read and is familiar with the Statement of Policy and Rules Governing Use of the Common Area of the Shopping Center (see reverse side) and recognizes and agrees by his signature hereto that the making of this Application, the issuance of any Permit based on this Application and the use authorized by such Permit are expressly conditional upon Applicant's acceptance and continuing observation of said Rules. Applicant agrees that if a Permit is issued pursuant to this Application, Applicant will indemnify and hold Management, the Owner, each tenant of the Shopping Center, and the Merchants Association harmless from and against any and all claims for personal injuries, death, damages, costs, and/or other expenses, including reasonable attorney's fees, arising from or in any way connected with the use of the Common Area of the Shopping Center or any part or facility thereof by the Applicant or his agents, members, partners, associates, Contractors, servants and employees, and the undersigned does hereby release, discharge and acquit the Owners of the real estate, their lessees, the Mall Management Company (and all their shareholders, directors, employees, customers and invitees), Mall Tenants (and their owners, officers, directors, employees, customers and invitees) and the Mall Merchants Association from any and all claims, demands, and actions for any loss, cost, expense, damage or injury either to the person or property of the Applicant and each member of the Applicant sustained by reason of any condition of said Common Area or the Mall Shopping Center, or due to any act of any employee or agent of the Merchants Association, the Mall Tenants, the fee Owner, its lessee, the Management Company or the act of any other person or entity whatsoever, all of which claims are hereby waived by Applicant for itself and each of its members.

The undersigned declares, under penalties of perjury, that the factual information furnished by him in this Application is true, accurate and complete to the best of his knowledge and belief.

Date: ______ Applicant *(Please Print)* ______

By (Signature) ______

Title, if any ______

Address ______

City ______ State ______ Zip ______

Phone ______

PERMIT TO USE COMMON AREA

The organization named above has received permission to use the Common Area during the stated hours on the stated date, subject to the established policies of the Shopping Center and to Rules and Regulations stated on the reverse side of this document.

Date ______ Authorized Signature ______

For ______

______ Permit denied, for the following reason(s): ______

Form CA 11073

STATEMENT OF POLICY

RULES AND REGULATIONS FOR NON-COMMERCIAL ACTIVITY WITHIN THE

1. The Management Company of the Shopping Center is pleased to permit non-commercial activities to be conducted within the enclosed pedestrain arcade or on the parking lots of Shopping Center (hereinafter called "Common Area") by interested persons and organizations (hereinafter called "Users"). To accommodate such Users in a manner and to an extent consonant with the primary purposes of the Shopping Center the Management adopted the rules and regulations contained herein in order to faciliate such use of the Common Areas."

2. The commercial activity of the Shopping Center and Mall, tenants, their owners, officers, directors, employees, customers and invitees are the primary activities of the Shopping Center. All other Users cannot conduct any other activity within the Shopping Center without having first obtained a permit for such activity from the Management. Such permit shall be granted only for use of that area designated as "Common Area."

3. Any User may apply for a permit for non-commercial activity within the Shopping Center at the Mall office of the Promotion Director during the hours of 9:00 to 4.00 p.m., Monday through Friday. Application shall be in the form set forth by the Management and subject to these rules and regulations and shall be made no later than 30 days prior to the day requested by the User for use of the "Common Area

4. In making a determination as to whether a permit for non-commercial activity within the Shopping Center shall be issued, Management shall evaluate the following: The nature of the activity; the dates times and duration of the activity; the risk of injury to any person or properties; the risk of unreasonable interference with the aforementioned commercial activities of Shopping Center tenants and their owners, officers, directors employees, customers and invitees. Management will consider applications on the first-come first-served basis and no application for a reasonable non-commercial activity within the Shopping Center will be denied.

5. Each User shall agree to be bound to comply with the following conditions and rules:

A. The activity shall be confined to a specific use of the "Common Area" as set forth in detail on the Application and will be limited to date and times specified on such Application and confined to the "Common Area" as determined by Management.

B. Users shall at all times during its use of the "Common Area" provide sufficient supervision and maintain adequate control of its members, guests or invitees.

C. In the event there are any licenses, or permits required by any governmental agency or authority with respect to the type of activity carried on, Users shall be responsible for obtaining such licenses, authorizations or permits. No unlawful activities shall be permitted in the use of the "Common Area" including but not limited to the use of alcoholic beverages or gambling.

D. All Users using the "Common Area" assumes liabilith for and shall indemnity and hold harmless the owners of the real estate, their lessees, the Management Company (and all their shareholders, directors, employees, customers and invitees), Shopping Center tenants (and their owners, officers, directors, employees, customers and invitees) and the Merchants' Association against and from any and all liabilities, obligations, losses, penalties, actions, suits, claims, damages, expenses, disbursements (including legal fees and expenses), or costs of any kind and nature whatsoever in any way relating to or arising out of any activity of the Users (including without limitation the activities of the User's members, officers, directors, employees, agents, contractors, servants within the Shopping Center) The Shopping Center tenants, the Merchants' Association, fee owner, its lessee, or the Management Company shall not be liable to any User using the "Common Area" or any other person on or about the enclosed Mall the adjoining grounds and parking lot, by the User's consent, invitation or license, express or implied, for any loss, expense or damage, either to the person or property sustained by reason of any condition of said "Common Area" or the Shopping Center, or due to any act of any employee or agent of the Association the Shopping Center tenants, the fee owner, its lessee, the Management Company or the act of any other person whatsoever.

E. If the Application is for any activity which may reasonably be expected to cause public disorder or injury to any person or property or to require substantial cleaning, repairs or restoration in order to return any area of the Shopping Center to the condition existing immediately prior to the commencement of the activity the Management may, as a condition to granting a permit require security for the performance of the applicant's obligation as licensee under such permit and these rules and regulations Such security shall be in a form satisfactory to the Management and may be a cash deposit, a bond, insurance policy, or other adequate assurance of the applicant's performance. Where such determination is made and insurance is required such insurance shall be in the minimum of a general comprehensive or public liability policy having limits of $100,000.00 for one person, $300,000.00 for one occurrence and property damage of $50,000.00 or a combined single limit policy of $300,000.00

F. Unless otherwise permitted by Management the User shall not vend or peddle, or solicit orders for sale or distribution of merchandise, devices, services, periodicals, books, pamphlets, tickets or other material whatsoever. User shall not exhibit any sign, plaque or banner, notice or any other written material in or around the Shopping Center without prior written approval by Management

G. The User shall not use any vehicle, motor, camera lighting device or projector on the "Common Area" without prior approval of Management. The User shall not engage in any fighting or direct or use any physical force, abusive or obscene language or theats toward any other person or engage in any oter form of unreasonable behavior such as the making of unreasonable noise or any coarse or offensive utterance, gesture or display, which causes or is likely to cause significent public inconvenience, annoyance or alarm. In addition, the User shall not permit the emission of noise or odors or use any devices or paraphernalia which may constitute a nuisance such as loud speakers, sound amplifiers radios televisions or phonographs without prior written approval by Management.

H. Any interested person or organization using the "Common Area" shall not engage in any conduct which might interfere with or impede the use of any other facility of the Shopping Center by any customer, business invitee or employee, employer, or tenant or create a disturbance, attract attention or harass annoy ~~disparage or be detrimental to any of the retail establishments of the~~ Shopping Center.

I. The "Common Area" shall be surrendered in the same condition as it was upon commencement of its use. All expenses incurred to maintain order and to keep the "Common Area" free from rubbish will be borne by the User.

J. The scheduled fee for the use of the "Common Area is ______

The hours the "Common Area" is to be open for use are as follows

10:00 A.M. to 9:00 P.M., Monday-Friday
10:00 A.M. to 5:30 P.M., Saturday
12:00 Noon to 5:30 P.M., Sunday

K. If the Management shall deem the use of the "Common Area" objectional, in its own discretion, it may, without any notice whatsoever, terminate the rights of the User to use the "Common Area." All such persons shall immediately remove themselves from the Shopping Center, the enclosed pedestrian arcade, and the adjoining grounds and parking lots.

L. All users of the "Common Area" shall, prior to occupying the "Area" for use, notify the Management Office of the Shopping Center at least 30 minutes before such use.

M. The User shall not obstruct the free flow of pedestrian or vehicular traffic on walkways, sidewalks, stairways, escalators roads driveways, parking lots or any other area regularly used for such traffic within the Shopping Center.

TO: ALL PERSONS REQUESTING USAGE OF COMMON AREA OF VALLEY WEST MALL

FROM: PROMOTION OFFICE

RE: COMMON AREA APPLICATION

Completing the attached Common Area Application for usage of Valley West Mall is a policy that must be adhered to for four reasons:

1. The form gives the promotional office a clearer understanding of the type of activity your group has planned.

2. The form if submitted 30 days in advance allows enough time to coordinate the equipment and supplies needed for the promotions set-up deadline. It is also required for insurance purposes.

3. The form serves as a source of reference for future promotional activities.

4. The form serves as a Hold Harmless Agreement between exhibitor and Valley West Mall.

Therefore, each person/group requesting usage of the Common Area must fill in all details on information requested. Please fill in the correct information on each line of the application.

Check below:

Exhibitor agrees to provide:

___ A) table(s) quantity _____
___ B) table draping-all tables must be draped
___ C) chairs quantity _____
___ D) booth draping
___ E) electricity
___ F) extension cord
___ G) staging
___ H) stanchions/roping
___ I) other ________________
___ J) other ________________
___ K) other ________________

Valley West Mall agrees to provide: -

_X_ A) chairs quantity 2 stools
___ B) electricity
___ C) extention cord
___ D) staging
___ E) stanchions/roping
_X_ F) other Community booth
___ G) other ________________
___ H) other ________________
___ I) service entrance for loading/unloading

Your cooperation in completing the check-list for equipment and the C.A.A. will insurance that no mistakes in arrangements will occur.

Thank You!

June 15, 1984

Mr. Larry Jessen
Crossroads Mall Management Office
5th Avenue South
Fort Dodge, Iowa 50501

Dear Mr. Jessen:

This is to request permission, per our recent phone conversation, to use a community booth at the Crossroads Center for distribution of about 200 copies of a questionnaire in conjunction with research I am currently conducting. The research involves drivers' perceptions of intersection right-of-way in certain situations. A copy of the questionnaire is enclosed for your review. Also enclosed is a copy of a supplementary information sheet for volunteer subjects under 18 years of age.

If this request meets with your approval, I would like to distribute the questionnaires on Monday, June 25, 1984. Please let me know what equipment I will need to provide of my own. If necessary, I can provide a card table, folding chair, and an easel for my 22 x 28 inch poster identifying me and my research effort.

Thank you for your consideration of this request.

Sincerely,

Robert E. Montgomery
Temporary Instructor

REM/ssa

CROSSROADS MALL
A FIRST UNION PROPERTY (515) 955-6340
5TH AVE. SO. (U.S. 20) AND SO. 25TH ST. FORT DODGE, IOWA 50501

June 18, 1984

Mr. Robert E. Montgomery
Iowa State University
Department of Civil Engineering
Ames, Iowa 50011

Mr. Montgomery:

I have reviewed your questionnaire and feel we can set up a booth for you.

You will be located in the J. C. Penney wing, and tables and chairs are available upon request. You may want to bring your easel to support your poster, although we do have sign holders that handle a 22 x 28 poster.

I have enclosed a map to indicate the approximate location for your display. Please stop by the mall office upon arrival to let us know you are here.

Sincerely,

Larry Jessen
General Manager
Crossroads Mall

LJ:lm

Enclosure

June 18, 1984

Mr. John Donner, Manager
J. C. Penney
Crossroads Center
Waterloo, Iowa 50702

Dear Mr. Donner:

This is to request permission, per our phone conversation this date, to utilize space at the second floor mall entrance to your store for distribution of about 200 copies of a questionnaire in conjunction with research I am currently conducting. The research involves drivers' perceptions of intersection right-of-way in certain situations. A copy of the questionnaire is enclosed for your review. Also enclosed is a copy of a supplementary information sheet for volunteer subjects under 18 years of age.

If this request meets with your approval, I would like to distribute the questionnaires on Sunday, June 24, 1984. I understand that I am to provide an easel for my 22 x 28 inch poster identifying me and my research effort.

Thank you for your consideration of this request.

Sincerely,

Robert E. Montgomery
Temporary Instructor

REM/ssa

Enclosures

June 21, 1984

Mr. Bob Montgomery
Dept. of Civil Engineering
Iowa State University
Ames, IA 50011

Dear Mr. Montgomery:

Please find enclosed a copy of the rules and regulations regarding use of the Kennedy Mall Public Service Booth. Please fill out the necessary information requested at the bottom and return the form to me ~~in the enclosed pre-addressed, stamped envelope.~~ Do call me should you have any further questions.

Sincerely,

Deborah K Powers

Deborah K. Powers
Marketing Director
KENNEDY MALL

Will be bringing with the morning of June 27th.

DKP/rg

Enclosure

KENNEDY MALL
PHONE 319 556-1994 • DUBUQUE, IOWA 52001

APPENDIX D: POSTER

LICENSED DRIVER SURVEY

I NEED LICENSED DRIVERS WHO WILL VOLUNTEER TO HELP ME WITH MY RESEARCH BY FILLING OUT A SIMPLE QUESTIONNAIRE. I'M BOB MONTGOMERY, A GRADUATE STUDENT IN CIVIL ENGINEERING AT IOWA STATE UNIVERSITY. IF YOU HAVE ANY QUESTIONS ABOUT THE CONDUCT OF THIS RESEARCH, PLEASE FEEL FREE TO CONTACT :

DR. R. L. CARSTENS
PROFESSOR-IN-CHARGE
TRANSPORTATION ENGINEERING
DEP'T. OF CIVIL ENGINEERING
IOWA STATE UNIVERSITY
AMES, IOWA 50011
PHONE: 515-294-6777

APPENDIX E: LETTER TO A COUNTY ENGINEER

Dept. of Civil Engineering
Iowa State University
Ames, Iowa 50011
October 25, 1984

Robert B. Sperry, P.E.
Webster County Courthouse
Fort Dodge, Iowa 50501

Dear Sir:

I am currently a graduate student in Civil Engineering at Iowa State University, working on a Ph.D. in Transportation Engineering. For my dissertation, I am conducting research on drivers' perception of right-of-way assignment at uncontrolled intersections. Analysis of over 500 questionnaire responses from a survey I conducted this past summer reveals that a sizeable proportion of licensed drivers in Iowa do not know which driver legally has the right-of-way when two drivers are simultaneously approaching a T intersection. The proportion of drivers not understanding similar situations at four-legged intersections is considerably smaller.

It is not clear whether this situation translates into a potential accident problem, such as different accident rates at four-legged and T intersections. To determine if this is the case, I need to develop a large data base of uncontrolled intersections (no STOP or YIELD signs). To assist in this effort, I would greatly appreciate it if you could supply me with a map of your county, preferably with a scale of one-half inch per mile, with either the controlled or the uncontrolled intersections (please indicate which) circled.

Since this is the time of the year for preparation for the approach of a new year, I appreciate the fact that such voluntary activities as I am requesting must hold a low priority in your work schedule. However, if you are able to comply with my request, I would appreciate it if you could supply the reqested information by early to mid-December, 1984. In appreciation of your cooperation in this matter, I would be most pleased to supply you with a summary of my results when my research is completed. Thank you very much.

Sincerely,

Robert E. Montgomery, P.E.

APPENDIX F: LETTER TO IOWA DOT REQUESTING ACCIDENT DATA

April 15, 1985

Robert D. Andresen
Office of Driver Services
Iowa Department of Transportation
Lucas State Office Building
Des Moines, Iowa 50319

Dear Mr. Andresen:

In conjunction with my research at Iowa State University on intersection accident rates, I would appreciate it if you would supply me with a printout of all accident record information on the ALAS system from January 1, 1977 through the most current information on the system for the following Howard County intersections (nodes):

45413325	45440133	45318181	45328133	45328181
45338101	45348181	45346549	45346533	45326565
45317325	45320981	45310925	45247349	45216541
45223325	45213341	45211717	45241749	45241781
45240181	45240149	45240133	45138149	45148133
45425741	45444965	45443389	45433301	45423381
45423373	45338981	45336501	45344949	45321709
45341733	45320909	45310941	45218117	45228981
45238133	45247333	45247317	45224189	45212557
45232533	45220981	45210133	45138165	45136501

Thank you for your handling of this request.

Sincerely,

Robert E. Montgomery, P.E.

REM/va