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ABSTRACT

A SURVEY OF SOUTHWESTERN NEW HAMPSHIRE DRIVERS' KNOWLEDGE OF SYMBOLIC SIGN MESSAGES

By

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Drivers' knowledge of symbolic sign messages that are employed as traffic control devices has not been reliably assessed. Symbolic messages have seen increasing use in recent years despite inconclusive evidence of driver knowledge.

The principal objective of this study was to assess driver's knowledge and recognition of symbol signs. Differences between groups of drivers, delineated by age, sex, driving experience, and training, were studied through the use of a fifteen item domain referenced test. The content validity of the instrument was set at r = .979 and reliability was set at r = .9455. The test sample was comprised of two hundred and twelve (212) drivers, selected on the basis of license renewal date, from southwestern New Hampshire.

The Pearson Product Moment and the Bi-Serial

correlation coefficients were employed to test association between test variables. Intragroup differences were measured using the t-test, ANOVA, the eta statistic, and the test of linearity.

The study results showed a strong linear relationship in the variable age, in that as age increased, symbol knowledge decreased. A significant difference of 5.168 between the mean test scores of male (81.571%) and female (76.404%) drivers was observed. Significant differences were also found within the eight driving experience classifications and a positive linear relationship was established. The presence of driver education among test subjects produced a mean score difference of +6.562. Sign recognition and sign knowledge were found to be related based on the obtained correlation coefficient of $r = .739$.

To my wife, Jackie

For accepting and sharing a goal
I have pursued;
for promoting this endeavor
when interest diminished; and,
for many hours of assistance
that is herein recognized.

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CHAPTER I

THE PROBLEM

Statement of the Problem

The problem addressed in this research was the assessment of drivers' knowledge of selected traffic symbol signs. A test was administered in December 1982 to southwestern New Hampshire drivers during the license renewal process. The study was intended to discern differences between groups of drivers, which were based on age, sex, training and driving experience, and their knowledge of the selected symbol signs.

Background of the Study

One of the primary controllable modes of information presented to drivers in the traffic environment is traffic signs. Messages on signs are essentially presented in two types: word and symbolic messages. The driving task involves the driver's ability to interpret the meaning of signs accurately under a wide variety of conditions and often with specific time limitations.

Symbol signs have been used as traffic control devices on the highways of this country almost since the invention of the automobile. In order to develop a more uniform motorist communication system, the federal government decided in the early 1970's to adopt some of the international symbol signs. Since then, symbol signs

have been demonstrated to be an effective form of communication with drivers in this country and in foreign countries. (1,8,14)

More than one hundred symbol signs have been accepted by the federal government for use on streets and highways. The major categories consist of regulatory, warning, guide, information and construction signs. There has been extensive use of symbol and pictographic signs in the traffic system. The greatest demand exists in the recreational and service sectors and can be seen widely in roadside advertising.

An interest in tourism and education in the United States, by foreign individuals, along with the growth of a multilingual population, creates a need for symbol signs in the transportation system. In some sections of the country, English has become the second language.

The science of symbol sign development involves very complex perceptual considerations that have been researched both here and abroad. Symbols do not necessarily change the content of a sign, but there is still difficulty in expressing content through symbols. The word message "road narrows" and the symbolic message are both intended to cover the same condition, but communicating the information so that there is a singular interpretation is difficult.

Relatively little research has been conducted to determine drivers' knowledge of the symbol signs since

their implementation, and no assessment has been made previously in the State of New Hampshire.

Purpose of the Study

Symbol signs and signs in general are intended to provide drivers information about roadway and traffic conditions in order to improve both safety and efficiency. The extent to which symbol signs accomplish this objective, and to which drivers understand the messages presented by the symbols, has not been adequately documented. The purpose of this study was to assess drivers' knowledge of selected symbol signs that are used as traffic control devices. A secondary purpose of the research was to determine drivers' familiarity with the selected signs.

This study was directed at identifying the symbol signs essential to the driving task that are most recognizable and those that are least recognizable. The audience(s) most affected by misinformation was also studied.

Public information accompanying the development and use of symbol signs has been limited at best. Symbol signs are generally considered to be self-evident and appear without word messages. Whether the signs are learned through trial and error or are self-explanatory is not clear. Driving experience was correlated with sign knowledge to obtain a partial answer to this questions.

The study was designed to answer the research questions relative to a selected group of symbol signs deemed most critical to the driving task by traffic experts. No attempt was made to determine drivers' knowledge of all symbol signs.

Significance of the Study

Since the institution of the system of symbol signs, little research emphasis has been placed on determining drivers' knowledge of these signs. Previous research (1,14) has centered on gathering information on symbology and the science of symbols. The characteristics of symbols, the attention demanded, and the message conveyed by abstract forms have received considerable attention from both the traffic and psychological research communities. (14,19)

Drivers rely almost entirely on information received from the traffic environment in performing the driving task. Processing the information accurately and rapidly is dependent, in part, on the quality and the form of the stimuli presented. Symbol signs are used to communicate messages in such a mode as only to require recognition and interpretation of the sign content without the need to comprehend and interpret the meaning of word messages. (1)

The study also intended to identify the groups, based on the study variables of age, sex, driving experience and training, in which symbol sign knowledge needs the most

improvement. Previous research has indicated deficiencies in certain age classifications of drivers. (1,2,5)

Large amounts of money are spent by the State of New Hampshire each year on the installation and maintenance of signs about which little is known regarding drivers' use and understanding. While previous research has employed laboratory techniques and intact groups, this effort tested a random sample of drivers using a valid and reliable test instrument.

The study provided information that can be applied to the transportation system to affect cost and efficiency. Cost is a factor in as much as some signs may be unnecessary or inappropriate for their purpose. Efficiency is considered from the standpoint of communicating a message in a clear and singular fashion. Public dissatisfaction with the traffic control devices used in the traffic system is voiced almost daily through the media and to governmental officials. (2) Traffic signs that do not convey the proper information or present inaccurate or easily misinterpreted information, are common on the highways.

An attempt was made to evaluate the input function of the driving task for the driver as an information processor. By comparison, output in the driving task is far simpler to measure than input. Information density and information processing capabilities are determining factors in the reception of stimuli from the environment

(13). The process of discrimination and the ability of the driver to discriminate affect input and the overall performance of the driving task. (13) The relationship of symbol sign research to this issue involves the ability of the driver to process information accurately and rapidly and the determination of the signs and symbols that effectively discriminate in presenting messages. Signs should discriminate in terms of form, content, and intensity. This study was intended to identify the signs of major importance and their ability to project a discriminating or singular message.

Recognition and understanding received emphasis in the study rather than the concepts of detection and identification. By assessing recognition and understanding, the question of what the information presented on the sign meant to the driving task was sought.

General Questions to be Answered

The major research questions answered by this study are as follows:

1. Do drivers in southwestern New Hampshire understand the meaning of selected symbol signs?
2. Are the variables of age, sex, driving experience, and formal training factors affecting drivers' understanding of symbol signs?
3. Have drivers seen or are they familiar with the

selected symbol signs in the traffic environment?

4. Are certain selected symbol signs better recognized and understood by drivers than other symbol signs?

Research Hypotheses

The null hypotheses tested in this research were:

1. There is no significant difference between male and female drivers' knowledge of symbol signs.

$H0_1$: $\mu_1 - \mu_2 = 0$

2. There is no significant difference in the knowledge of symbol signs between drivers with formal training and those without formal training in the driving task.

$H0_2$: $\mu_1 - \mu_2 = 0$

3. There is no significant difference in the knowledge of symbol signs between the age classifications of drivers.

$H0_3$: $\mu_1 - \mu_2 - \mu_3 - \mu_4 - \mu_5 - \mu_6 - \mu_7 = 0$

4. There is no significant difference in the knowledge of symbol signs between the experience classifications of drivers.

$H0_4$: $\mu_1 - \mu_2 - \mu_3 - \mu_4 - \mu_5 - \mu_6 - \mu_7 - \mu_8 = 0$

The level of significance for all statistical tests was set at .10.

Basic Assumptions

Four assumptions were made in conducting this research:

1. The content validity and reliability of the test instrument, established as part of the research, were sufficient for the purposes of this study.
2. Individual responses of the test subjects were based on true symbol sign knowledge.
3. Symbol sign knowledge can be tested through the use of a valid and reliable test instrument.
4. Expressed opinions are held opinions.

Delimitations

For the purposes of this study, the following delimitations were established:

1. New Hampshire residents are eligible to obtain a drivers license at age 16 with the renewal required at three year intervals. Age groupings were set at 16-19, 20-29, 30-39, 40-49, 50-59, 60-69, and 70 and older.
2. The symbol test was administered to drivers who were scheduled for renewals during the month of December in 1982.
3. Only drivers from southwestern New Hampshire were tested as a part of this study. New license and out of state transfer applicants were not tested.

Definition of Terms

1. SYMBOL SIGNS: The internationally accepted emblem and picture signs, without accompanying words, used to provide information to drivers.
2. DRIVING EXPERIENCE: For the purposes of this study, a value representing the number of miles driven by a driver in a period of one week.
3. FORMAL TRAINING: The completion of a formal driver education course as a prerequisite to licensing.
4. WORD MESSAGES: The statement or legend accompanying a symbol sign to provide the driver a second source of information about the sign. (9)
5. KNOWLEDGE: The driver's understanding, awareness, and comprehension of the symbol sign message.
6. FAMILIARITY: The fact of whether or not a driver has seen or recognized a symbol sign.
7. DOMAIN-REFERENCED TEST: A test instrument using a sample of questions to evaluate a body of knowledge.
8. DIAGRAMATIC SIGN: A sign using symbolic messages to indicate a path of travel on a highway. (14)
9. DISCRIMINATION: The ability to distinguish between confusing or ambiguous stimuli from the

driving environment; the presentation of a singular message by a symbol. (14)

10. DETECTION: The perceptual act of seeing a symbol sign in the traffic environment.
11. IDENTIFICATION: The act of being able to accurately name the symbol sign seen in the traffic environment.
12. RECOGNITION: The act of being able to interpret the meaning of the message of a symbol sign seen in the traffic environment.
13. VISUAL CUES: The elements of color, contrast, motion, intensity, and position, that serve as visual stimuli in the traffic environment.
14. PICTOGRAPHIC SIGNS: Signs employing picture symbols as opposed to abstract symbols to communicate a message. (16)

Summary

In the preceding discussion, a need has been indicated for symbol sign research and for the investigation of the relationship between the test variables and symbol sign knowledge.

Chapter Two of this report presents findings of previous sign research that was applicable to this study. The relationship between sign messages and the driving task is defined as well as related research methodologies.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The majority of the research conducted in relation to symbol signs has focused on the individual characteristics of the signs such as legibility distance, attention value, and understanding of the message symbol. No comprehensive study has been found to date that deals with all the essential tasks of detecting, recognizing, and acting on a wide variety of symbol signs, using a true random sample of the driving population.

Historical Perspective

In 1949 the United Nations Protocol for Standardized Signs was adopted in an attempt to bring a degree of uniformity to the international motorists' communications networks. It was not until 1962, through the work of several Japanese citizens, that the International Committee for Breaking the Language Barrier was established in New York. This organization proposed the adoption of symbols as an international traffic communication medium and actively lobbied for implementation.

The 1962 United Nations Conference on Road Signs produced a rudimentary guide for international signs but not all were symbolic in nature. Relatively few countries participated in the development of the sign proposal and

thus, it received only modest support. (13)

In preparation for the 1964 Olympics, the Japanese government became the first to adopt symbol signs in a uniform manner. (It is interesting to note that both the Chinese and the Japanese alphabets are derived from symbolic representations for use as characters.) Soon after, the United Kingdom and the Canadian province of Quebec instituted symbol sign systems for their highways. (10)

Not until 1971 did the United States government adopt a limited number of symbol signs for use on highways. A year earlier, the U.S. Park Service implemented a system of symbol signs in parks and other recreational areas in order to better accommodate foreign visitors. Since the mid-1970's, the United States has devised a system of symbol signs for highway communications and provided for extensive implementation. However, this system is not in full accord with the standardized internationally accepted symbols. (13)

The Benefits of Symbol Signs

The benefits of signs employing symbols to communicate messages (symbol, diagrammatic, and changeable message signs) have not been clearly defined in sign research. Mast and Kolsrud (14) conducted a study that indicated diagrammatic signs produce tangible benefits in sizable reductions in hazardous maneuvers, improved lane positioning, and in reduced indecision at gore areas.

Their field study suggested that the greatest benefits are derived in areas where unexpected or unusual maneuvers are common.

Multiple message displays incorporating symbols can address a broader range of traffic management problems and roadway and environmental conditions, according to the research findings of Allen, et al. (1). These signs also have the advantage of being able to inform drivers of the type of action(s) required for a given situation with specific information.

Symbols convey information in much the same way as conventional signs except that no reading skills are utilized in the communication process. The accuracy of well designed symbols in conveying an intended message is very high. Not only can a symbol be used to present a condition or situation with one statement but the degree and intensity can also be communicated to the audience. (4)

For example, Roberts (17) found that diagrammatic signs more adequately communicate the driver's position relative to an exit within an interchange than conventional signs. An advantage is gained by having the operator visualize the approach to the interchange prior to entering the area where decisions are demanded. The decisions on position and direction are then mentally stored and the task becomes one of updating and executing the decisions.

Drory and Shinar (6) described several drawbacks of symbols used as communication devices. The foremost

problem was that as the graphic component(s) of the sign became more complicated, the time required by the driver to interpret the information increased. Drivers also need additional time to read and interpret the information displayed on complex diagrammatic signs in comparison to conventional signs. Intricate graphics increase the information content in the sign message but at the same time place increased processing demands on the vehicle operator.

Allen (1) found that some diagrammatic and symbol signs may actually enhance the problems drivers encounter at interchanges with single right exits, common cloverleaf, and very complex interchanges by producing indecision. This situation leads to two general recommendations regarding the use of symbols. First, simple graphic designs must be employed whether the message is complex or elementary. Sensory overloads are as much a consideration in signs as in roadway design. The second recommendation, involving response time, remains an essential consideration even though the information content of the sign is heightened by a symbol without additional verbage. A major variable is the processing and execution time needed after the sign has been observed and the information content transmitted to the driver. (1)

The Transportation Research Board (TRB) (18) determined that cost tends to be a factor in favor of symbol signs; especially in comparison with the application

of diagrammatic and changeable message signs. Special symbols and legends demand individualized construction at additional cost. Maintenance and installation costs are much higher for the diagrammatic and changeable message signs than for mass produced conventional signs.

Most benefits are derived from the ability of the symbolic representations to transmit simple and meaningful messages without the use of lengthy legends, according to Allen.(1) The integrity and density of the information content presents both positive and negative results depending upon the specific application. The function of the symbol sign is limited though by the variable abilities of vehicle operators who have widely divergent capabilities in perceiving, processing, and acting on the information transmitted. (1)

Effectiveness of Symbol Signs

Most research supports the superior performance of symbol signs in communicating messages as compared to conventional signs. Diagrammatic signs, changeable message signs, and symbol signs are more effective in most situations requiring special or detailed applications due to the specialized design to fit the demands. As described earlier, the information content of the symbol is greater and requires significantly less reading and response time than conventional signs. The effectiveness of symbol signs is directly related to the attention value of the design

and this element may, in fact, be the key to transmission of information. (6,14,18) Allen (1) demonstrated that symbol signs provide legibility as good as, and in many cases better than, conventional word message signs.

In the same study, Allen (1) investigated the influence of the geometric complexity of the graphics in establishing inherent meaning. He found that increasing the geometric complexity tended to make the symbol more obvious. Symbols with inherent meaning were more easily recognizable and may be immediately familiar to the driver upon initial exposure. Complex graphics make the symbol distinctive and isolate its meaning from outside interference. Singular meaning is essential to a symbol and when attained, the application was limited to those situations and demands most appropriate to the design.

Allen (1) also compared the single symbol to a single word employed on a sign. The two were equivalent and required a little over two seconds for reading and comprehension by the driver. This fixation was relatively long when combined with other driving tasks. Warning signs, according to Drory and Shinar (6), receive shorter fixations than directional signs. Most symbol signs fall into the warning classification which may account for the shorter fixations. The symbols used in warning signs are generally simple in both content and context. The directional signs employ more graphically complex symbols and word messages by necessity in order to communicate

sufficient information to guide motorists.

When signs have the capacity to present multiple messages using several symbols or words, TRB (18) findings define the advantages over single message signs. Single message signs are appropriate only when the situation is recurrent and the same driver response is solicited each time the sign is encountered. They are applicable for only the intended purpose and the accuracy and credibility of the sign is questionable over time. The multiple message signs can alert drivers to a broad range of problems without presenting unnecessary distractors.

TRB research findings indicated that reading and comprehension should increase for multiple message signs if simply the bulk and complexity of the information displayed is considered. Longer scanning and fixation times are also implied. At issue is whether or not the multiple message sign improves the quality of the information reception process while increasing the fixation times. While the process of perception is questionable, the fact that the multiple message sign improves the attention of the driver by providing variable information is a decided advantage. (18)

Legibility, recognition time and efficiency in presenting the sign message are the most obvious benefits of symbolic messages. When the complexity of the symbol is sufficient to increase the reading and comprehension times this element becomes a detriment unless adequate response

time is allocated to the driver in each application. (18)

Roberts (11) defined the attention value of diagrammatic guide signs as seeming to be greater than that of conventional signs, which is probably due to the increased size of the legend. The symbols used on diagrammatic guide signs presented a more formidable character for viewing than conventional word messages. An essential element of any sign, symbol signs included, was the attention value inherent to the design. Attention value was the degree to which the sign components collectively demanded observation or review by the driver.

The yellow/black warning signs were described by Allen (1) as having the highest attention value of all signs while the white on green service signs have the second best recognition. Although the white on green had high attention values, it also produced some of the highest rates of recognition errors. Allen cited geometric complexity of the symbol as a second crucial factor, but it also produced other perceptual elements influencing driver recognition and behavior, as described earlier. Attention value was determined by visual cues such as color, contrast, motion, intensity, position, size, repetition, and shape. These factors caused drivers to visually divert attention from one orientation to another.

Communicability of information to drivers is the basic requirement of all signs. Roberts (17) studied the communicability of symbolic messages and discovered that

they more clearly presented information relative to exit directions at advanced locations than did conventional signs. Mast and Kolsrud (14) corroborated this finding in research showing that diagrammatic signs produced the greatest benefits where unexpected or unusual maneuvers can be anticipated. The diagrams of the exit areas, lanes and routes clearly defined driver choices and removed from the driving task the necessity to read and respond to lengthy word messages within a short time span.

Multiple message signs can address a broader range of traffic, roadway, and environmental situations, according to research by the TRB (18). These signs are most effective in alerting drivers to the conditions they are to encounter and in informing them of the appropriate actions required in the specific situation.

In conducting a study on the effectiveness of changeable message signs, the TRB (18) found that the efficiency of regulatory, advisory, and warning signs, was nearly impossible to quantify because of the factors producing bias in the study. The difficulty was in determining whether the test sign or a later relevant cue affected driving behavior. As the efficiency of the symbolic message improves, the demand placed on the driver increases while the time required for recognition decreases. Symbol signs are not appropriate in every situation as some very complex conditions are virtually impossible to represent accurately with simple graphics.

The TRB study did determine that the changeable message sign was a step up from the conventional symbol signs with regard to attention value. Problems existed however, with fully reliable data that would allow the researchers to quantify the difference. The greatest value of the changeable message signs was in communicating information under adverse weather and roadway conditions.

The requirements for traffic control devices defined in the Manual on Uniform Traffic Control Devices for Streets and Highways (16) are all essential in insuring the effectiveness of signs. The effectiveness of sign messages is dependent upon proper application of the sign, attention value of the graphics, selective or limited use, and a clearly recognizable message.

Perception and Recognition of Symbol Signs

Drory and Shinar (6) asserted that traffic control devices are used to inform drivers about something that the roadway or the environment does not or cannot inform them. Signs provide response time to situations that are not known to the driver. Markowitz, Lees, et al., (13) defined a classification of probability signs or those intended to inform the driver of some condition or hazard that may exist in the traffic environment. The driver's response was determined by the probability that the condition(s) described by the sign exists in the environment. Past experiences and environmental stimulus

were evaluated to assess the potential of the hazard or condition being present.

Earlier discussion by Allen (1) noted that the attention value of a symbol is a dominant factor in driver recognition and understanding. Drory and Shinar's (6) research into the attention value of signs also defined several principles of driver attention. They found that as the demands of the driving task increase, the individual differences between drivers, i.e. fatigue, emotional state, etc., are reduced as more mental capacity is required. When the situations presented in the driving environment are less demanding, the individual differences become more pronounced. Fatigue can be suppressed temporarily if the attention demanded of the driver is at a high level, but as the demands diminish, the driver may relax to the point of being inattentive.

Drory and Shinar (6) stated that the upper limit of sign recognition is determined by attention. The attention value of the sign and the attention of the driver to the driving task are both relevant. When the driving task demands attention, such as with a winding road, attention increases and so does sign recognition. Their research used road design factors as a study variable.

A 1969 study of symbol recognition, conducted in Ottowa, Canada, by McLean (15), used a questionnaire to test eight sign symbols. The symbols selected for study

were: No Parking, No Stopping, One Hour Parking, Pavement Narrows, Bump, Construction Flagman, Slippery Road Ahead, and One Lane Traffic. Three of the symbols exhibited a high degree of recognition: the "P" used as a substitute for the word "parking," Flagman Ahead, and Slippery Road Ahead. The research report specified neither the criteria employed to define a high degree of recognition nor the symbol sign selection criteria.

Gordon (8) conducted research on the subject using diagrammatic and conventional signs. While diagrammatic and symbol signs are not equivalent, the design concepts (avoiding word messages) are the same. In six of the ten locations studied, reaction time for the diagrammatic signs was shorter. Two of the locations reached significance at the .05 level using a t-test for corrected measures where N=30. The test measures were based on the speed and accuracy of the subjects lane changes as determined by observers. Reaction time demanded recognition on the part of the driver. Some of the diagrammatic signs were more suitable and effective for particular interchange designs. Conventional signs did produce fewer lane placement and selection errors.

Gordon's findings support the assertions made in other research that symbols and diagrams are more effective in low task load situations but that the value of the signs begins to decline as the complexity of the tasks increase. The research on sign recognition does not

clarify the apparent contradiction between the improved response time produced through the use of symbols and the degradation of responses and maneuvers when symbols are employed in complex situations. The fact that the subjects in Gordon's study expressed a personal preference for conventional signs may be indicative of driver acceptance of the symbols that do not appear as "friendly." Other research cited previously described the difficulty of expressing complex situations with graphics. Recognition is improved when the route and destination information is matched with the major diagrammatic components of the sign, according to Roberts (17). The components of the sign allow the driver to be more discriminating when making lane selection and travel direction decisions. Graphic and situational complexity tend to be less problematic in the presence of adequate discriminating symbol qualities.

Markowitz, Lees, et al. (13), determined that the shape of the sign has no inherent meaning to drivers and that it is probably the least important design element. But since shape is helpful for sign recognition in some cases (stop, yield and other singular purpose shapes), the effect on recognition must be considered.

The research of Mackie (12), Dewar (4), Roberts (17), Drory and Shinar (6), and others depended upon recall of signs when driving. The classic experiment asked the subject to specify a sign that had been passed when

stopped after travelling through a test area. Drory and Shinar (6) claimed that recall is related to attentional and motivational factors rather than those of memory or sensory inputs. There was a failure to account for the process and effect of discrimination as a perceptual consideration in these studies.

Drivers' Knowledge of Symbol Signs

Kato (11) proposed ten criteria for the development of symbol signs with universality. These recommendations serve as some of the primary test criteria in the design of symbolic messages.

1. Is it easy to associate the symbol with its message?
2. Does the symbol fit different cultures and different local situations?
3. Does the symbol fit the changing times?
4. Is the symbol pleasing and acceptable without controversy?
5. Does the symbol conform with existing international symbols or other elements?
6. Is the symbol or its element capable of systematic application for a variety of interrelated concepts?
7. Is the symbol easily reproducible? Is it applicable for many different purposes?
8. Is the symbol distinguishable from other symbols?

9. Can the sign be perceived from different angles and perspectives, under different light conditions?
10. Can the symbol withstand vandalism and contamination?

In a 1966 study entitled Progress in Learning the Meaning of Symbolic Traffic Signs, (12) Mackie administered a questionnaire to 476 drivers to test their knowledge of symbolic traffic signs. The instrument was designed to collect data relative to the understanding of the shapes, colors, and meanings of the signs. The variables consisted of age, sex, social class, geographic area, and experience driving outside of the country. A secondary area of concern centered on the method of learning the meaning of the symbol signs.

When compared to a similar test conducted in 1965, Mackie observed significant differences in several areas. The mean value of knowledge on identical test items improved 16% in the latter study ($P < .001$). While the percentage of correct answers increased, the percentage of incorrect answers remained constant. The difference was accounted for through a reduction in the number of partly correct responses.

The most widely recognized symbol sign was the Advanced Warning - Traffic Signal Ahead sign, which had almost universal recognition. The least recognized symbol sign was the Parking Regulation grouping.

Two important factors identified in the research are that seeing the sign while driving was an indicator of drivers' knowledge of the symbol signs, but not the complete answer, and that the most common method of learning signs was self reported to be guessing.

There was an inconsistent level of knowledge among the groups of British drivers on the various symbol signs. No significant differences were reported between male and female drivers but there were significant variations between knowledge and age. The drivers who knew the principles of the sign classification system (3% of the population) gave significantly more correct responses than drivers who did not know the classification system. (12)

Similar findings were reported by Dewar and Swandon (5) in a 1971 report. They found no significant differences in Canadian drivers with regard to sex, but again established a significantly lower level of knowledge among older drivers; especially those over 60 years of age. Driver education was identified as having a possible enhancing effect on knowledge of certain classes of signs, but not all.

Their research produced evidence suggesting that older drivers take longer to process sign information and have less knowledge of signs in general. The testing

revealed that response distance decreased with age for several reasons:

1. poorer dynamic visual acuity;
2. greater time required for perception, recognition and response due to increased processing time; and,
3. unfamiliar settings.

Important implications are seen in the above elements when considering sign placement and educational programs with respect to populations over sixty years of age.

Dewar and Swanson (5) determined that "the evidence comparing symbols with word messages in traffic control signs is inconclusive and insufficient." A major inconsistency exists in the design of symbolic messages in that some represent hazards and others represent risks. Whether the sign issues a positive or negative connotation (a do or do not command) was also identified as an area of conflict.

These researchers have defined the most important design and test criteria in terms of what action the driver will take in response to the symbolic message. In related work, Dewar (4) determined that symbol signs provided legibility as good as, and in many cases superior to, word messages. The symbols were the equivalent of single words and as such, required a little over two seconds for reading and comprehension while providing needed information.

An early study by Janda and Volk (10) found that directional control was best provided by an arrow (i.e. symbol) alone. The effectiveness of sign messages was defined from highest to lowest as symbol alone, to symbol and words, to words alone.

Additional research involving symbol signs was conducted by the American Automobile Association's (AAA) Foundation for Traffic Safety. (2) In a 1980 study entitled Motorists Understanding of Traffic Control Devices, Test II, a research test film was used to evaluate drivers' understanding of traffic control devices in traffic situations. Nineteen traffic situations were used to test signs, signals, and markings. A nationwide sample of 1700 drivers from civic, fraternal, and other intact groups participated in the study.

AAA also found a wide variance in the understanding of traffic control devices, which encompasses pavement markings and traffic signals in addition to signs. There was no significant difference between the male and female drivers tested but older drivers' knowledge tested at a level significantly below that of younger drivers. The study determined that symbol signs were better understood than either traffic signals or pavement markings. The highest level of performance was established when testing the Railroad Crossing, the Advance Warning - Stop, and the Advance Warning - Yield signs. Poor performance was exhibited on the Exit Only and standard Yield signs, while

the Continuous Lane and the No Merge Required signs produced the lowest levels of performance.

A field study by Drory and Shinar (6) demonstrated that only six percent of drivers questioned could recall the study sign after driving past the test site and that nine percent could recognize the sign when pictured on a sheet depicting warning signs. The researchers cited factors of fatigue, size of the vehicle, absence of passengers and sex as determinants in recognition. The measure used to determine fatigue produced a correlation of .62 in predicting sign recall.

The types of training employed by both Mackie (12) and Dewar (4) in their research showed no appreciable influence in enhancing test subject scores. Dewar used pamphlets, educational plaques and combined the techniques without significant results. While age has been shown to be a factor in initial testing of knowledge, all age groups learned an approximately equal number of signs during the symbol sign training sessions conducted by Dewar as a treatment after pre-testing.

Symbol Sign Testing Techniques

Test and population variables were relatively consistent among the studies reviewed in this literature search. Mackie (12) tested knowledge of symbol signs over the widest range of variables. He included social class, age, sex, driving experience outside of the country, and

area of residence for the British subjects. Several of the classifications contained small groups of subjects, especially in the older populations, and the analysis was limited. AAA (2) used the variables of age, sex, and region of the country for a test of 1700 U.S. drivers in 1980 while Allen et al. (1) tested drivers on the basis of age, sex and training.

Age was the one variable showing the greatest differences in almost all research. Allen, et al. (1), Mackie (12), Dewar (4), and AAA (2) drew similar conclusions from their tests. In general, sign knowledge decreased with age. Older drivers' performances were the worst on regulatory symbol signs and were particularly bad on prohibitory signs. Allen suggested that since the regulatory signs contain a large number of directional signs with similar or related meaning and symbols, they create confusion for older drivers and require longer perception and reaction times. The only variable consistently showing no significant differences was sex.

Most of the testing has avoided any task loading and utilized static rather than dynamic presentation. Notable exceptions are the studies by AAA (2), which used simulation,and the field studies by Markowitz (13), Drory and Shinar (6), and Mast and Kolsrud (14).

Test procedures covered a wide variety of techniques in both the field and laboratory research. Testing has been conducted using questionnaires, simulation and films,

mechanical testing, and field observations and tests.

Drory and Shinar (6) stopped vehicles 200 meters beyond a sign in a test in their field studies, but limited their analysis to only passenger vehicle occupants. The selection of the vehicles was not random as platoons of vehicles were not stopped and vehicles were permitted to pass if there was the potential to inhibit the free flow of traffic. Other field studies used observers or mechanical testing and recording units to analyze drivers' responses to signs.

Dewar and Swanson (5) conducted laboratory tests of drivers' knowledge of symbol signs in Canada. City employees and driver education students were introduced to all test signs and given the meaning prior to the test to insure that all symbol signs were familiar. The testing consisted of showing a slide projection of the sign in the traffic environment and the subjects were required to write the appropriate driving action on the answer sheet. Mackie (12) and AAA (2) employed paper and pencil testing and driving simulation respectively. AAA produced a special test film of nineteen traffic sign, signal, and marking situations. A questionnaire, corresponding to the film, was used to record the subjects' responses to the traffic situations.

Allen (1) and AAA incorporated aspects of training into the testing process. Allen applied three treatments to subjects consisting of signs and educational plaques,

pamphlets explaining the signs, and a combination of the two techniques. No significant differences were found on the effects of knowledge. AAA provided feedback to the test subjects by means of a specially treated questionnaire that would reveal the correct answer when a chemical marker was used to color the answer circle. If the correct circle was colored, the work "ok" would appear.

Markowitz, Lees, et al. (13) were the only researchers to deviate from the correct/incorrect designations for responses. They utilized strictly correct, generally correct, irrelevant, and contradictory, in assessing drivers' actions when approaching complex interchanges in a field study. The other research involved the selection of the appropriate response or classification, as in the case of a questionnaire. Few of the questionnaires allowed open-ended responses i.e., no answers were presented and the subjects were required to write a response. Dewar (4) did not report any difficulty with this methodology but an unpublished study by Emery (7) found that drivers could not formulate responses.

Field testing and laboratory testing of symbol signs necessitates the application of different techniques and purposes. McLean (15) devised a field test with a test construction site to evaluate drivers' responses to construction zone signing. Driver actions were recorded on video tape and a questionnaire was administered after passing through the area. Dewar (4) cited significant

problems with field studies in that a strict set of common operational definitions is not available for such terms as conflict, erratic maneuver, lane selection error, etc. Not only is it difficult to measure these variables but replicating the research is impossible. Driver feedback is also a limiting factor.

The value of field studies is that an indication of drivers' response to a symbol sign can be observed in some situations. Also, true environmental conditions are incorporated in the studies and task-loading is present.

Laboratory studies, on the other hand, have four major short-falls, according to Dewar (4). The test item presentation is usually not in random order and random selection of subjects has been difficult to obtain. Laboratory studies also lack normal visual cues and distractions found in the driving environment and static testing tends to be a draw-back as the reaction and decision time factors are often eliminated.

Symbol sign experiments generally measured only one factor in the complex process of sign perception, recognition, and volition. As stated earlier, the majority of all sign research has centered on legibility and visibility. The ability of the symbol sign to communicate a message is well defined. Dewar (4) suggests that the most important aspect of symbol sign testing should be the ease with which the sign can be learned and remembered.

Several studies were designed to evaluate a single sign or a group of signs and, as such, selection criteria are not applicable. AAA (2), Mackie (12), and Dewar (4) neglected to provide any rationale for the selection of symbol signs to be tested.

Allen, et al., (1) provides the most comprehensive assessment in this regard in establishing a goal of developing a balanced presentation of symbol signs. The primary criteria considered were:

1. Levels of semantic complexity; and,
2. Different types and colors of signs.

Twelve signs from each of the six categories of signs, as defined in the Manual on Uniform Traffic Control Devices for Streets and Highways, were included.

After ranking the signs in the group for complexity within the group, Allen's selection was based on:

1. Universality of usage;
2. Availability of good quality art work;
3. Minimal redundancy; and,
4. High semantic or geometric complexity.

Each of the categories included signs of different shapes, colors, and contrast conditions. Several complex signs were selected for high semantic and/or geometric complexity that would not otherwise have been included in the groups. Emery (7) selected signs that were listed in the State Drivers' Manual (Michigan) and those that were new or had changed color.

Dewar (4) contended that the information available on the methodologies for symbol sign testing was inadequate. A review of literature on sign testing shows that many studies employed poor methods or poor research design. In evaluating knowledge, Dewar recommended the use of a multiple choice test instrument showing a picture or drawing of the sign and asking for the meaning or driver action. Showing a film with the sign in context could also be used. The same approach could be appropriate for legibility testing.

Designing a research study for symbol signs requires a comprehensive approach incorporating several methodologies. Dewar suggests that no single method is totally adequate for any sign research since each sign factor: meaning, attention value, legibility, processing time, influence on driving behavior, (and resistance to habituation), needs to be addressed in a unique fashion. The methodologies and designs reviewed in studies for this research have not been especially rigorous.

Symbol Sign Design

This discussion is limited to the design elements of symbol signs and some more general sign consideration. Extensive information is presented in the Traffic Engineering Handbook (9) and the Manual on Uniform Traffic Control Devices for Streets and Highways (16).

The essential symbol sign design criteria, according

to Markowitz, Lees, et al., (13) was to determine the information needs of the driver in each specific traffic situation. This could be accomplished by categorizing the drivers into user groups and then directing the symbol or sign to the audience. Signs must be specific to the task and yet applicable to a general audience.

Six driver considerations, relative to signs, were discussed in the Traffic Engineering Handbook.

1. Interpretation - word and symbol sign messages must be reviewed for all possible interpretations and misinterpretations.

2. Continuity - signs must be designed in context with the other signs so as not to create conflicts with similar signs in the system.

3. Advance Notice - signs must allow adequate response time for the driver in each situation.

4. Relatability - sign messages should be presented in the same information terms as identical information would be available to the driver from other sources.

5. Prominence - the design of the sign should be able to supercede other demands for driver attention.

6. Unusual Maneuvers - signing should be designed to give drivers information at points where unusual or unexpected maneuvers take place.

These considerations establish direction for the designers of traffic control devices and especially for symbolic messages.

Markowitz (13) also defined symbol design criteria with emphasis on the information content and

communicability of the message. His recommendations consisted of:

1. Each symbol should give all important information in the statement it is picturing and present the elements of information in priority order.
2. The symbol should contain no unnecessary detail that may distort the message being presented.
3. Commonality (with other symbols used in society) should be incorporated whenever possible to improve recognition of the symbol.

These criteria referred to the contextual design of the symbol rather than the graphics. The necessary information must be combined with as few irrelevant cues as possible to avoid misinterpretation by the driver.

In discussing symbol signs, McLean (15) states that every element of a sign is in fact a symbol: shape, color, background, and object or graphics. All sign elements convey meaning through symbolism and this is true even with some word messages. Drivers use the shape of the sign to perceive meaning in much the same way that the graphics are utilized.

Stop, Yield, No Passing, and Railroad Crossing signs are examples of single classification signs. Markowitz (13) claims that there is very little application of this type of sign in the traffic system despite their high level of effectiveness. The single classification signs

have limited attention except for the intended users, for whom the impact is greatest. A related classification of symbol signs, not employed in this country, involves abstract images to present information. These symbols are best suited for critical messages and, as with the single classification signs, require intensive education of the driving public upon installation. Allen (1), investigating recognition distance of symbols, found that correctness and longer perception distances are achieved through the use of bold, simple, and unique graphics. Symbols that convey a message with the least contradiction and ambiguity in design are the most effective.

McLean (15) best describes the dilemma in symbol sign design when he asserts that traffic and highway engineers feel that they are sufficiently expert in signs and symbols to design new signs themselves when, in fact, more disciplines may need to be included. Symbols are becoming widely used throughout our society to convey messages and the transportation system has been flooded with uniform and non-uniform issues alike. The discipline of highway symbol design and application is not sufficiently developed. The multidisciplinary and inter-disciplinary approaches necessary to design effective symbol signs have not been brought to bear on the problem.

Summary

The available research clearly demonstrated some major gaps in what is known about drivers' understanding of symbol signs. The research by AAA (2) did not employ a true random sample and used only five actual symbol signs in the test. Two of the five signs have been consistently identified in other research as being the most widely understood and recognized of all symbol signs.

No study has produced a significant correlation between symbol sign knowledge and sex, yet differences have been found within the age categories. The effects of driving experience and driver education are not well defined but both tend to enhance performance of symbol sign tests. Performance on tests of the familiarity with the symbols provided inconsistent results.

A strong indicator identified in the Mackie research was the drivers' knowledge of the symbol sign classification system, which, unfortunately, is not utilized with standardized symbol signs in the United States.

The research methodologies in the studies reviewed did not address the reliability and validity of the instruments, criteria for determining when drivers know and do not know the meaning of a sign, and test sign selection criteria. These items are critical to reliable research.

No research assessed the impact of discrimination upon sign knowledge or of the influence of discrimination as a source of invalidity. There was no resolution of the contradiction between task loading and the reduced effectiveness of symbol signs and the improved response time achieved through the application of symbols. Research design has not accommodated these issues.

Symbol design is in its early stages of development in this country and elsewhere. While symbols are widely used, the interdisciplinary and multidisciplinary approaches needed for comprehensive design consideration have not been instituted.

The primary benefits of symbolic messages are the more immediate and accurate understanding of the sign, and the elimination of the need for language comprehension. In multilingual and mobile societies, these elements are becoming necessities.

In Chapter III, a description of the research design and methodology is presented. The data collection and analysis are also discussed in detail.

CHAPTER III

DESIGN AND METHODOLOGY OF THE STUDY

The principal objective of this study was to assess drivers' knowledge of selected traffic signs employing symbolic messages. The study was intended to discern differences between groups of drivers, which were based on age, sex, driving experience and training, and their knowledge of the selected symbol signs. A secondary objective was to determine drivers' familiarity with symbol signs.

Chapter II reviewed literature and studies relevant to these objectives, ie., knowledge and familiarity. This chapter deals with the following areas: (1) source of data; (2) materials; (3) procedure of the study; (4) research design; and, (5) procedure for analysis of data.

Source of Data

A test sample was drawn from drivers in southwestern New Hampshire who were renewing their driver/operator licenses. Permission was obtained from the Division of Driver Licensing, Department of Safety, in New Hampshire, to test renewal applicants at the testing stations after they were administered the eye examination and before they received their renewed photo license. Drivers were randomly assigned renewal appointments by the Division of Driver Licensing during the month of their birth.

Sample Employed

Two hundred and twenty-three examinees were administered the test instrument for this study in December 1982 during the license renewal process at stations in Keene and Hillsborough, New Hampshire. All renewal applicants holding valid licenses and having driven during the past year were tested. No discrimination, in context of race, creed, age, sex, or national origin, was exercised.

Subjects could not be required to complete the test as it was not part of the state license renewal examination. Drivers were asked to complete the test, though, as a part of the renewal process without being given any option. By prior agreement with the Division of Driver Licensing, any driver who refused to take part in the test would be excused without recourse. One male and four female subjects, approximately two percent of the test population, declined to respond to the test questions.

Eleven test returns were eventually eliminated due to either illegibility or failure to meet the past year driving criteria. The final sample size consisted of 212 drivers who met all test requirements as specified above.

Research Materials

The materials for this study were limited to a fifteen question multiple-choice test, a response sheet for demographics and item answers, and pencils. The test instrument and response sheet are presented in Appendix A. The test instrument was developed specifically for this

research project after an extensive search of related literature failed to produce suitable items. Item bank searches did not contain an acceptable number or quality of questions with established validity or reliability to meet the demands of this study. A summary of the process employed in developing the instrumentation is presented here, with a detailed description in Appendix B.

The instrument consisted of a fifteen item domain-referenced test with an additional five items for demographic information. Each multiple choice question was presented with three foils accompanied by a full color sign for reference to the item. Only upper case letters in 10 pitch were used in the type style to facilitate ease of reading. The average reading level for the four pages of the test was determined to be at a 4.2 grade level and ranged from 3.0 to 5.5 for the entire instrument. Dr. Glenna Mize, Reading Specialist in the Safety Center at Keene State College, estimated the reading level for the twenty items using the Frye Readability Formula. The reading level assessment is found in Appendix C.

Symbol signs of true color were obtained from the pamphlet United States Road Symbol Signs (October 1979), printed by the Federal Highway Administration, U.S. Department of Transportation, and affixed to the form for each item. The pages of the instrument were laminated and stapled to enhance durability.

The basis of sign selection for research purposes was noted

as a deficiency in prior studies. A serious attempt was made to rectify this situation by developing a logical and systematic selection procedure.

This study employed a process of content validity to identify and select the signs deemed most important to the driving task. Items were developed by the author for each of the fifty-five symbol signs listed by the U.S. Department of Transportation in the pamphlet noted above. Four traffic engineering, traffic safety, and driver licensing experts were asked to evaluate and rate each item following the content validity assessment process developed by Mussio and Smith in Content Validity: A Procedural Manual.

Each expert was given a description of the content domain to be tested and the test questions, and asked to rate the relevance of the item to the domain using a five point scale. The recommendations and ratings of the experts were recorded on the assessment form and the interrater agreement and index of content validity were calculated.

The fifteen symbol signs receiving the highest average ranking by the four experts were selected for inclusion in the study. These signs were determined by the panel of experts to be the most essential to the driving task. A detailed discussion of this process, and the accompanying materials, is presented in Appendix B.

Statistical analysis consisted of applying

Kuder-Richardson Formula 21' (K-R21') to the ratings provided by the four experts to obtain a correlation representing interrater reliability and an index of content validity. The index of content validity was established at a level of r=.9455.

The level of reliability of the instrument was established in conjunction with the pilot study and set at r=.979. The discussion of test instrument reliability occurs elsewhere in this chapter under Research Design.

Procedure of the Study

Testing during the driver licensing process provided an ideal setting and opportunity for this study. No time requirements were established for the respondents and thus no task loading was incorporated into the data collection process. The official environment of the testing station was used to promote acceptance of the testing.

The license renewal process in New Hampshire is initiated with a renewal appointment issued to each licensed driver in the state at four year intervals. Renewal appointments are made during the month of birth of the licensee on a random basis as the renewal applications are returned to the state office.

The setting within the testing stations consists of a vision screening and photo area along with another area for new driver licensing testing. After successful completion of the vision test, the licensee has a photo identification picture taken and must wait from three to fifteen minutes

for processing of the official license. It was during this normal waiting period that the test subjects were asked to complete the questionnaire.

Immediately after the photo was taken and before the licensee exited the testing area, he or she was asked to participate in the survey. The following approach was used in each case:

> "We are conducting a survey of driver's knowledge of signs and I would like you to answer some questions on signs while you wait for your license photo to be developed."

After an indication of approval, each subject was given a test form, answer sheet, pencil, and the following instructions:

> "Please begin by responding to the first five questions on the answer sheet to give some information about yourself. For each question, circle the letter of the answer that is most appropriate for you. Then go on to the sign questions, read the question and select either 'A,' 'B,' or 'C' as the correct answer. For each question, record your response on the answer sheet by circling the letter you selected. You do not need to put your name on the answer sheet and please do not write on the test form. Please return the completed forms to me when you have finished."

The only action required of the subject was to read the item and circle the appropriate letter response on the answer sheet. No time limit was placed on the subject in responding to the items. Assistance was provided only to subjects who asked to have the instructions repeated.

Five of the licensees approached declined to complete the survey. No reason was given in these cases and none was requested. Upon return of the questionnaire the

respondents were thanked for their participation, given their licenses, and exited the area. The test items were neither scored nor answered before the subjects' departure.

Tests were administered at the testing stations in Keene and Hillsborough, New Hampshire. The majority of all renewal applicants are assigned to Keene as it is the population center of the southwestern region. Hillsborough was randomly selected from among the three part-time testing stations to provide a representative sample of drivers from outside Keene.

A total of two hundred and twenty-three (223) renewal applicants was tested. One hundred and eighty-one (181) drivers were tested in Keene on December 1, 2, 8, and 9, 1982. The remaining forty-three (43) were tested in Hillsborough on December 9, 1982. The distribution of Keene and Hillsborough subjects is roughly equivalent to the population distribution within Keene and outside of Keene in the testing region.

Research Design

A pilot study was conducted prior to formal testing to assess the data collection procedures and to gather results to establish the reliability of the instrumentation. In the pilot study, the test was administered to fifty (50) licensees. The proposed methodology for test administration was evaluated and found to be acceptable, based on low test subject procedural errors and

receptivity. No modifications were made to the instructions, test materials, or method of presentation at the close of the two days of pilot test. The pages of the test form were laminated after the trial period because of wear due to license applicants writing on the instrument.

Test reliability was established as a part of the pilot study as no measure existed for the new instrument. Kuder-Richardson formula 21' was selected for this assessment because of its accuracy of estimation. The formula employed in the calculations was:

$$K\text{-}R\ 21' = 1 - \frac{.8M\ (K-M)}{KV^2}$$

In this formula:

M=the mean of the test scores
K=the number of items in the test
V^2=the variance of the scores.

The following values were obtained from the tests:

M=12.38
K=15
V^2=31.7556

These calculations produced a coefficient of reliability for the test instrument of: r=.9455. This level of reliability was acceptable for the research purposes when considered along with the level of validity of r=.979. Coefficients in this range are considered exceptional in test construction when a level of .90 is usually most acceptable.

Research Hypotheses

The null hypotheses tested in this research were:

1. There is no significant difference between male and female drivers' knowledge of symbol signs.

HO_1: $\mu_1 - \mu_2 = 0$

2. There is no significant difference in the knowledge of symbol signs between drivers with formal training and those without formal training in the driving task.

HO_2: $\mu_1 - \mu_2 = 0$

3. There is no significant difference in the knowledge of symbol signs between the age classifications of drivers.

HO_3: $\mu_1 - \mu_2 - \mu_3 - \mu_4 - \mu_5 - \mu_6 - \mu_7 = 0$

4. There is no significant difference in the knowledge of symbol signs between the experience classifications of drivers.

HO_4: $\mu_1 - \mu_2 - \mu_3 - \mu_4 - \mu_5 - \mu_6 - \mu_7 - \mu_8 = 0$

The level of significance for all statistical tests was set at .10.

Procedure for Analysis of Data

The validity and the reliability of the instrumentation were determined prior to data collection as described above. Two hundred and twenty-three (223) sets of data were collected and two hundred and twelve (212) were utilized.

All of the response sheets utilized in the data

analysis were individually numbered for identification purposes, hand keyed to electronic media, and stored on diskette. This entire process was duplicated producing two complete data files that were loaded into the Digital/Vax 11/780 at Keene State College for comparison of the two data files. An input error rate of .0026 was registered and errors were reconciled against the original forms.

SPSS for VAX/VMS, Version M. Release 9.1, June 15, 1982, was selected as the program for statistical analysis. The descriptive statistics (frequencies) were generated through the use of the CROSSTAB feature. The intragroup statistics were computed through the use of "Procedure Breakdown" and "Procedure T-Test" in SCSS for the variables of age, driving experience, sex and training. The interactive SCSS statistical analysis program, running on the Wang VS100, was employed to cross check data, perform exploratory analysis, and for table generation.

Differences in subgroup population means were tested as follows:

Variable Name	Statistical Test(s)
Age	Eta, ANOVA, Linearity
Sex	t-test
Driving Experience	Eta, ANOVA, Linearity
Training	t-test

Each item on the instrument was analyzed and the frequency of each response to an item calculated. Null responses were also tabulated to assess guessing. Drivers' recognition of the symbol signs tested was computed at this

time and included as a descriptive statistic. The Pearson Product Moment Correlation was employed to test the strength of association between sign recognition rates and correct response rates.

Statistical analysis of the relationships between the groups and their knowledge of symbol signs was accomplished using Pearson Product Moment and Point Bi-serial correlations. The relationships between knowledge and the variables of sex and training, both dicotomous, was computed using the Point Bi-serial correlation. The Pearson Product Moment correlation was employed to test the relationship between the variables of age and driving experience, both continuous, and knowledge of symbol signs.

Summary

A test instrument was employed to determine drivers' knowledge of symbol signs during the license renewal examination. A fifteen item domain-referenced test instrument was developed for the study and it was determined to have very high validity and reliability coefficients. The instrument was constructed with high legibility and readability. The sample consisted of two hundred and twelve licensed drivers from southwestern New Hampshire. Computerized data analysis was conducted using SPSS and SCSS. The results of the data analysis are presented in Chapter IV.

CHAPTER IV

ANALYSIS OF DATA

In Chapter Three, the methods and procedures of test development and data collection for this study were discussed. A domain referenced test was administered to two hundred and twelve subjects, randomly selected on the basis of license renewal appointment date and date of birth. The data obtained was analyzed using SPSS and the interactive SCSS.

Chapter Four provides a presentation and analysis of the data collected. The elements of this chapter consist of 1) Demographic Information; 2) Test Item Analysis; and, 3) Crosstabulations and Intragroup Statistics.

Demographic Information

Age and Sex

The age of the respondents was grouped into seven categories as detailed in Table 1, which also summarizes the breakdown by sex. Of the two hundred and twelve respondents, six were in the sixteen to nineteen (16-19) age group; fifty-five in the twenty to twenty-nine (20-29) group; sixty-two in the thirty to thirty-nine (30-39) group; thirty-seven in the forty to forty-nine (40-49) group; thirty-one in the fifty to fifty-nine (50-59) group; fifteen in the sixty to sixty-nine (60-69) group; and, six in the seventy and over (70+) age group. One hundred and

Table 1

Age and Sex Distributions for Test Subjects

AGE	N	TOTAL %	CUMULATIVE %
(16-19)	6	2.8	2.8
(20-29)	55	25.9	28.8
(30-39)	62	29.2	58.0
(40-49)	37	17.5	75.5
(50-59)	31	14.6	90.1
(60-69)	15	7.1	97.2
(70+)	6	2.8	100.0
TOTAL	212	100.0	

SEX	N	TOTAL %	CUMULATIVE %
FEMALE	114	53.8	53.8
MALE	98	46.2	100.0
TOTAL	212	100.0	

fourteen (53.8%) of the respondents were female and ninety-eight (46.2%) were male.

Driving Experience and Driver Education

Driving experience was assessed as a factor of the number of miles driven per week by each respondent. The mean for this sample population equaled 135 miles per week. A breakdown of the eight categories is presented in Table 2 on the following page.

In the study sample, two drivers reported averaging zero (0) miles per week; thirteen reported one to twenty (1-20) miles per week; fifty-four reported twenty to fifty (20-50) miles per week; sixty reported fifty to one hundred (50-100) miles per week; forty reported one hundred to two

hundred (100-200) per week; twenty reported two hundred to three hundred (200-300) miles per week; five reported three hundred to four hundred (300-400) miles per week; and, seventeen reported driving an average of more than four hundred (400+) miles per week.

The influence of formal training, i.e. driver education, on symbol sign knowledge was analyzed as a part of this project and is also presented in Table 2. One hundred and eleven (52.4%) of the respondents had taken a course in driver education. One hundred and one, or 47.6%, had no formal training.

Table 2

Breakdown of Driving Experience and Training for Test Subjects

MILES	N	TOTAL %	CUMULATIVE %
DRIVING EXPERIENCE IN MILES PER WEEK			
0	2	.9	.9
1-20	13	6.1	7.1
20-50	54	25.5	32.5
50-100	60	28.3	60.8
100-200	41	19.3	80.2
200-300	20	9.4	89.6
300-400	5	2.4	92.0
400+	17	8.0	100.0
TOTAL	212	100.0	
MILES	N	TOTAL %	CUMULATIVE %
TRAINING			
DRIVER EDUCATION	101	47.6	47.6
NO DRIVER EDUCATION	111	52.4	100.0
TOTAL	212	100.0	

The fifth demographic item on the test instrument was a data check to verify a parameter of the study. A "no" response to the fifth question, "Have you driven a motor vehicle during the past year?", served to disqualify the answers from the data analysis session. The research definition for this project included only drivers who had driven during the past year.

Test Item Analysis

This section of the report summarizes the responses to the fifteen test items used to assess knowledge of symbol signs. A copy of the test instrument is found in Appendix A and in Appendix E, Tables E-1 through E-15 are used to present a breakdown of the responses to each test item. Crosstabulations are used in another section of this chapter to present test results with reference to the sample subgroups of age, sex, driving experience and training.

The grand mean for the symbol sign test was 78.792%, indicating that the test subjects, on the average, correctly responded to 11.8 of the fifteen items. The average recognition rate (whether or not the sign had been seen before) for all fifteen signs was 68.6%.

The effects of symbol sign recognition on symbol sign knowledge were analyzed by testing the relationship between the correct response rate and the recognition rate for each

item. The Pearson Product Moment Correlation was employed to test the association between the correct response rate and the recognition rate for the fifteen test items. A mean value of 78.76% was obtained for the fifteen items and a mean value for the recognition rate was set at 68.6%. The Pearson Correlation coefficient between the two sets of data was $r = .739$, which was significant at the .001 level. Missing values, i.e. no response, were found for 3.71% of the possible item response cases.

Table 3 shows the correct and incorrect response rates for each test item and the symbol sign recognition rates.

Table 3

Summary Table: Correct Response and Recognition Rate for Test Items

					NO		SIGN RECOGNITION			
ITEM #	CORRECT	%	INCORRECT	%	ANSWER	%	0	YES	NO	%
1	181	85.4	28	13.2	3	1.4	3	187	22	88.2
2	126	59.4	84	39.7	2	0.9	4	199	9	93.8
3	178	84.0	25	11.8	9	4.2	5	128	79	60.4
4	200	94.3	10	4.8	2	0.9	3	205	4	96.7
5	61	28.8	125	57.9	26	12.3	2	49	161	23.1
6	200	94.3	12	5.6	0	0.0	0	206	6	97.2
7	170	80.2	27	12.7	15	7.1	2	117	93	55.2
8	175	82.5	34	16.1	3	1.4	4	173	35	81.6
9	152	71.7	52	26.5	8	3.8	6	149	57	70.3
10	151	71.2	49	25.2	12	5.7	5	129	78	60.8
11	193	91.0	15	7.1	4	1.9	4	178	21	84.0
12	202	95.3	6	2.8	4	1.9	3	191	18	90.1
13	176	83.0	14	6.6	22	10.4	6	48	158	22.6
14	132	62.3	72	34.0	8	3.8	5	98	109	46.2
15	208	98.1	4	1.9	0	0.0	5	176	31	83.0
MEAN VALUES		78.8%				3.71%				68.6%

r = .793 SIGNIFICANT AT .001 LEVEL

Listed below, in order of correct response rate, are the symbol signs employed in this study. The classification of the symbol sign, ie. Warning, Regulatory, or Construction, is given as a W, R, or C respectively.

RANK	SYMBOL SIGNS (CLASS)	CORRECT RESPONSE RATE
1.	TWO WAY TRAFFIC (W)	98.1%
2.	LOW CLEARANCE (W)	95.3%
3.	DO NOT ENTER (R)	94.3%
4.	RIGHT CURVE (W)	94.4%
5.	SLIPPERY ROAD (W)	91.0%
6.	NO LEFT TURN (R)	85.4%
7.	KEEP LEFT (R)	84.0%
8.	NARROW BRIDGE (W)	83.0%
9.	MERGING TRAFFIC (W)	82.5%
10.	T-INTERSECTION (W)	80.2%
11.	MERGE LEFT (W)	71.7%
12.	DIVIDED HIGHWAY AHEAD (W)	71.2%
13.	WORKERS ON ROAD (C)	62.3%
14.	LEFT TURN ONLY (R)	59.4%
15.	CENTER LANE LEFT TURN ONLY (R)	28.8%

MEAN = 78.8%

Crosstabulations and Intragroup Statistics

In SCSS, "Procedure Crosstabs" and "Procedure Breakdown" were applied to the data to produce a variety of crosstabulations to test for differences in subgroup means and to establish measures of association within the sample subgroups. These functions produced frequency distributions, the statistical tests for correlations, t-tests, and ANOVA. Crosstabulations and breakdowns were produced for the variable pairs of:

1. Knowledge with Age;
2. Knowledge with Sex;
3. Knowledge with Driving Experience; and,
4. Knowledge with Training.

'Procedure Crosstabs' in SCSS provides for the calculation of measures of association between joint distributions of two or more variables. 'Procedure Breakdown' allows the calculation of general measures of central tendency, analysis of variance, and linear relationships. Both analytical tools can be used to generate tables and graphs to present summary data.

The correlations applied to test for association were the Pearson Product Moment Correlation and the Point Bi-Serial Correlation. The Bi-Serial Correlation is a special case of Pearson that permits one of the variables to be expressed as a dicotomous variable while the other has integer values. Both statistical tests used the same

formula but the Bi-Serial Correlation used a dicotomous variable coded 0,1 and an integer variable, rather than the two customary integer variables for the Pearson Product Moment Correlation. In reading any of the following computer generated tables, the listed Pearson value is the Bi-Serial value only when noted.

The t-test was used to test for differences in subgroup means within the variables of sex and training. ANOVA was applied to test for differences between the multiple subgroup means of the variables of age and driving experience. Linearity was also tested as an element of the analysis of these later variables.

Multiple breakdowns were performed using "Procedure Breakdown" in SCSS for five variable sets to describe differences within and between groups. Each table presented in Appendix D describes the mean, standard deviation, and number of cases for all subgroups of the variables. These breakdowns included:

1. Mean Test Scores by Sex and Training;
2. Mean Test Scores by Age and Sex;
3. Mean Test Scores by Age and Training;
4. Mean Test Scores by Experience and Sex; and,
5. Mean Test Scores by Experience and Training.

Analysis of the Variable Age

The Pearson Product Moment was used to test the level of association between the variables of age and knowledge

and a coefficient of r = -.272, which was significant at the 0.000 level, was produced.

Testing the differences between the subgroup means involved three tests: Eta, ANOVA, and a test of linearity. The null hypothesis stated there were no significant differences between the subgroups in the variable age. A statistical presentation of the variable age is found in Table 4. The mean test scores, broken down by age and sex, and by age and training, are presented in Appendix D of this report.

Table 4

Breakdown of Knowledge Test Scores by Age Groups

ETA, ETA SQRD = .3539 .1253
CORRELATION = -.2723
SIGNIFICANCE = 0.000

	Age Groups							
	1.	2.	3.	4.	5.	6.	7.	TOTAL
	16-19	20-29	30-39	40-49	50-59	60-69	70+	
MEAN	85.667	80.218	83.355	80.378	69.548	68.933	74.333	78.792
SUM	514.000	4412.000	5168.000	2974.000	2156.000	1034.000	446.000	16704.000
STD DEV	6.653	16.341	10.496	13.933	17.804	15.563	11.690	15.073
VARIANCE	44.267	267.026	110.167	194.131	316.989	242.210	136.667	227.198
N	6	55	62	37	31	15	6	212

The ANOVA statistic tested the equality of the seven subgroup means by analyzing observed variability. The obtained value of F = 4.8930, significant at the .0001 level, indicated that the means were probably unequal. With F = 4.8930, significant at a level of .0001, it was highly unlikely that equality of the means existed. Significant differences existed between the subgroup means of the variable age.

An index of the variability attributed to the differences between the subgroup means is the Eta statistic. The variability due to subgroup mean differences in the age variable was .1253.

Linearity was tested to assess the presence of a linear relationship between age and knowledge. The obtained F-value of 17.3772, significant at the 0.0000 level, indicated a strong linear relationship. The null hypothesis that no significant differences existed between the subgroup means was rejected.

A summary of the Eta, ANOVA, and linearity tests follows in Table 5.

Table 5

Summary of Statistical Analysis for the Variable Age

BREAKDOWN OF KNOWLEDGE - TEST SCORE

ETA, ETA SQRD = .3539 .1253
CORRELATION = .2723

ONEWAY ANOVA:	SUM OF SQUARES	DEG FR	MEAN SQUARE
BETWEEN GROUPS	6005.3124	6	1000.8854
WITHIN GROUPS	41933.5555	205	204.5539
TOTAL	47938.8679	211	

F = 4.8930*

TEST OF LINEARITY:	SUM OF SQUARES	DEG FR	MEAN SQUARE
LINEARITY	3554.5809	1	3554.5809
DEV FROM LINEARITY	2450.7316	5	490.1463

F(LINEARITY) = 17.3772**
F(DEVIATION) = 2.3962***

*SIGNIFICANT AT .0001 LEVEL
**SIGNIFICANT AT .0000 LEVEL
***SIGNIFICANT AT .0387 LEVEL

Analysis of the Variable Sex

The two categories within the variable sex were coded 0 for female respondents and 1 for male respondents. To test the level of association, the Bi-Serial Correlation was computed and a value of r = .171 was derived. The correlation was significant at the 0.006 level.

A t-test was applied to assess the differences between the mean scores for male and female test subjects. For male subjects the mean equaled 81.919 and a mean of 75.356 was obtained for female subjects with standard deviations

of 12.352 and 16.691 respectively. A t-value of 2.54, significant at the .012 level, was obtained. The null hypothesis that no significant differences existed between male and female subjects was rejected.

Table 6 details summary statistics from the t-test for the variable sex.

TABLE 6

T-Test Results for Male and Female Subjects in the Variable Sex

VARIABLE GROUP	N	MEAN	STD DEV	STD ERR
MALE	98	81.571	14.087	1.423
FEMALE	114	76.404	15.538	1.455

SEPARATE VARIANCE

DIFFERENCE BETWEEN GROUPS

VARIABLE	MEAN	STD ERR	t	DF	PROB
KNOWLEDGE	5.168	2.035	2.54*	209	.012

* SIGNIFICANT AT .012 LEVEL

Analysis of the Variable Driving Experience

The relationship between the variables of driving experience and knowledge was tested with the Pearson Product Moment Correlation. A value of r = .226, which was significant at the 0.000 level, was obtained. The breakdown of the variable driving experience is presented in Table 7.

Table 7

Cell Statistics for the Variable Driving Experience

BREAKDOWN OF KNOWLEDGE - TEST SCORE

ACROSS - DRIVING EXPERIENCE (IN MILES PER WEEK)

	LOW	MILES PER WEEK					HIGH	
LEVEL	1.	2.	3.	4.	5.	6.	7.	8.	
	0	1-20	20-50	50-100	100-200	200-300	300-400	400+	TOTAL
MEAN	73.500	68.769	77.241	78.667	79.317	80.700	82.800	87.765	78.792
STD DEV	9.192	20.187	14.182	17.296	13.648	10.147	9.960	10.680	15.073
VARIANCE	84.500	407.526	201.130	299.141	186.272	102.958	99.200	114.066	227.198
N	2	13	54	60	41	20	5	17	212

The mean test scores for the variable driving experience, broken down by sex and by training, are presented in Appendix D of this report.

Testing the differences between the subgroup means of the variable driving experience involved the Eta statistic, ANOVA, and a test of linearity. ANOVA was employed to test the equality between the eight subgroup means of the variable driving experience. The obtained F-value of 1.9634 was significant at the 0.0616 level and suggested that the subgroup means were probably not equal. A probability of 0.0616 indicates that it was unlikely that equality of the subgroup means existed.

The variability that could be attributed to differences in subgroup means was calculated using the Eta statistic. Subgroup mean differences accounted for .0631 of the variability.

The absence of a linear relationship was tested between the variables of driving experience and knowledge. An obtained F-value of 11.1502, which was significant at the 0.001 level, revealed the presence of a strong linear relationship.

Based on these tests, the null hypothesis that no subgroup differences existed in the variable driving experience was rejected.

Table 8 contains a summary of the Eta, ANOVA, and linearity statistics for the variable driving experience.

Table 8

Summary of Statistical Analysis for the Variable Driving Experience

ETA, ETA SQRD = .2512, .0631

ONEWAY ANOVA:	SUM OF SQUARES	DEG FR	MEAN SQUARE
BETWEEN GROUPS	3025.9197	7	432.2742
WITHIN GROUPS	44912.9483	204	220.1615
TOTAL	47938.8679	211	

F = 1.9634*

TEST OF LINEARITY:	SUM OF SQUARES	DEG FR	MEAN SQUARE
LINEARITY	2454.8342	1	2454.8342
DEV FROM LINEARITY	571.0854	6	95.1809

F(LINEARITY) = 11.1502**
F(DEVIATION) = .4323***

*SIGNIFICANT AT .0616 LEVEL
**SIGNIFICANT AT .0010 LEVEL
***SIGNIFICANT AT .8568 LEVEL

Analysis of the Variable Training

The two categories within the variable training were tested for their level of association using the Bi-Serial Correlation. A coefficient of r = .171 was obtained, which was significant at the 0.006 level.

In applying the t-test to assess the differences between the mean scores of subjects, a mean of 81.919 was obtained for subjects who had completed a course in driver education. The mean for subjects who had not taken a driver education course was 75.356. The difference between

the subgroup means was 6.562 and a t-value of 3.19, significant at the 0.002 level, was derived from the computations. As a result of the significant differences between the subgroup means, the null hypothesis that no differences existed, was rejected.

Test statistics for the variable training are summarized in Table 9. Mean test scores for subjects with training and without training, broken down by sex, are presented in Appendix D.

Table 9

t-Test Results for the Variable Training

GROUP 1: TRAINING (DRIVER EDUCATION)
GROUP 2: NO TRAINING (NO DRIVER EDUCATION)

VARIABLE GRP	N	MEAN	STD DEV	STD ERR
GROUP 1	111	81.919	12.352	1.172
GROUP 2	101	75.356	16.994	1.691

SEPARATE VARIANCE

DIFFERENCE BETWEEN GROUPS

VARIABLE	MEAN	STD ERR	t	DF	PROB
KNOWLEDGE	6.562	2.058	3.19*	181	.002

*SIGNIFICANT AT .002 LEVEL

SUMMARY

Statistical analysis of the test data, using SPSS and SCSS, produced a variety of descriptive statistics covering demographic features and item analysis. Also generated were the tests of association using Pearson Product Moment and Bi-Serial correlations. At a third level, the Eta statistic, ANOVA, and a test of linearity were employed to analyze differences between the subgroup means for each of the variables.

Each of the four null hypotheses were rejected. A level of significance of 0.10 had been established as a basic parameter for decision making in accepting or rejecting the null hypothesis. Significant differences were found in the subgroup means for the variables of age, sex, driving experience and training. In all cases, the probability of obtaining the observed results by chance was less than 0.10.

The item analysis identified the symbol signs that were most frequently identified correctly and incorrectly by the test subjects. Two Way Traffic, Low Clearance, Slippery Road, Right Curve, and Do Not Enter, all received correct response rates in excess of 90%. Symbol signs registering incorrect response rates below 75% were: Center Lane Left Turn Only; Right Turn Only; Workers On Road (Construction); Merge Left; and, Divided Highway Ahead.

An assessment of the relationship between having seen the symbol sign while driving (recognition) and knowledge of the sign (correct response) was performed. A Pearson Product Moment Correlation coefficient of r = .739 was obtained. This result was significant at the 0.001 level.

Findings, conclusions, recommendations, and discussion relevant to this study are found in the following chapter. A correlation matrix for the test variables is presented in Appendix D.

CHAPTER FIVE

SUMMARY, FINDINGS, CONCLUSIONS, RECOMMENDATIONS, AND DISCUSSION

The final chapter of this report will present: 1) a summary of the study; 2) conclusions based on the findings of the research; 3) recommendations for further study; and, 4) a discussion of relevant issues.

Summary

The principal objective of this study was to assess driver's knowledge and recognition of symbol signs used in the traffic environment. The differences between groups of drivers, delineated on the basis of age, sex, driving experience, and training were studied.

A fifteen item domain referenced test instrument, shown in Appendix A, was developed for this study and employed as the medium for assessing driver knowledge of symbol signs. The content validity of the instrument, set at r = .979, was established using a panel of traffic experts. Test validity was determined through a field trial after which the Kuder-Richardson Formula 21' (K-R 21') was applied to the test results. The level of validity was set at r = .9455.

The test sample was comprised of two hundred and twelve (212) drivers, selected on the basis of license renewal date, from southwestern New Hampshire who were renewing their driver/operator licenses. Tests were

administered during December 1982 at the licensing stations in Keene, Peterborough, and Hillsborough.

Data analysis was performed using both SPSS and the interactive SCSS. In addition to test item analysis, the association between the study variables and the knowledge scores was calculated using the Pearson Product Moment and the Bi-Serial correlation coefficients as appropriate. Intragroup differences were measured using the t-test, ANOVA, the eta statistic, and the test of linearity.

Findings

With respect to the data analysis, this study answered several questions:

1. Is there a significant difference in the knowledge of symbol signs between the age classifications of drivers?

Based on mean scores for each of the seven subgroups of the variable age, it was determined that age was a factor in symbol sign knowledge. The strong linear relationship along the groups showed that as age increased, symbol knowledge decreased. Over the individual test subjects, the Pearson Product Moment correlation also demonstrated the same age relationship with a negative correlation value.

2. Is there a significant difference between male and female drivers' knowledge of symbol signs?

The difference of 5.168 between the mean test scores of male (81.571) and female (76.404) drivers was

significant. In breaking down sex difference by age, male drivers achieved higher mean scores than their female counterparts in all age categories.

3. Is there a significant difference in symbol sign knowledge between the driving experience classification of drivers?

The Pearson Product Moment correlation showed a significant relationship between the number of miles driven per week and the knowledge scores of individual drivers. The positive correlation demonstrated that as mileage increased so did test scores. Significant differences were also found within the eight experience classifications and a positive linear relationship was established. A breakdown of the driving experience variable by sex did not produce a clear definition of differences.

4. Is there a significant difference in the knowledge of symbol signs between drivers with formal training and those without formal training in the driving task?

The presence of driver education among test subjects resulted in the mean score difference of +6.562. The difference between the mean scores for drivers with driver education (81.919) and those without driver education (75.356) was found to be significant. Clear definitions of differences were produced in breaking down training by sex and driving experience. The differences in mean scores by sex held up in the presence of training, as did the

reported differences produced by driving experience.

The effects of symbol sign recognition were analyzed by testing the relationship between the correct response rate for each test item and the corresponding recognition rate. Sign recognition and sign knowledge were related based on the obtained correlation coefficient of r = .739.

Fifteen symbol signs, used to provide information in the traffic environment, were tested in this study. Each sign was identified as critical to the driving task by the panel of experts. Listed below, in order of correct response rate, are the symbol signs employed in this study.

RANK	SYMBOL SIGNS (CLASS)	CORRECT RESPONSE RATE
1.	TWO WAY TRAFFIC (W)	98.1%
2.	LOW CLEARANCE (W)	95.3%
3.	DO NOT ENTER (R)	94.3%
4.	RIGHT CURVE (W)	94.4%
5.	SLIPPERY ROAD (W)	91.0%
6.	NO LEFT TURN (R)	85.4%
7.	KEEP LEFT (R)	84.0%
8.	NARROW BRIDGE (W)	83.0%
9.	MERGING TRAFFIC (W)	82.5%
10.	T-INTERSECTION (W)	80.2%
11.	MERGE LEFT (W)	71.7%
12.	DIVIDED HIGHWAY AHEAD (W)	71.2%
13.	WORKERS ON ROAD (C)	62.3%
14.	LEFT TURN ONLY (R)	59.4%
15.	CENTER LANE LEFT TURN ONLY (R)	28.8%

Conclusions

Based on the data analysis, this study produced the following conclusions.

1. Younger drivers are more knowledgeable of symbol signs than older drivers.

2. Male drivers are more knowledgeable of symbol signs than female drivers.

3. Exposure to symbol signs, as measured in miles driven per week, influences a driver's knowledge of symbolic messages.

4. Driver education has a significant positive impact on knowledge of symbol signs.

5. There is a strong relationship between symbol sign knowledge and whether or not the symbol sign has been seen by the test subject. Symbol sign recognition influences knowledge.

6. The best known symbol signs are Two Way Traffic, Low Clearance, Do Not Enter, Right Curve, and Slippery When Wet.

7. The least known symbol signs are Center Lane Left Turn Only, Left Turn Only, Workers On Road, and Merge Left.

Recommendations for Further Study

1. This study should be replicated in a larger geographic area, with an increased sample size to validate these findings. A wider demographic distribution will reduce the effects of any possible unknown and uncontrolled variables.

2. The scope of the test instrument should be expanded to include signs that present opposite or conflicting meanings in order to test drivers ability to discriminate between such signs.

3. The symbol sign test should be converted to another medium, such as photographic slides, in order to present the sign in a traffic scene with appropriate distractions.

4. A study should be designed and conducted to assess the efficiency of symbol signs in presenting messages in the traffic environment.

5. Other types of traffic control devices, ie. delineators and pavement markings, that are used in conjunction with symbol signs, should be studied to assess the potential for presenting conflicting messages.

6. Finally, a further assessment should be conducted to determine the source of the positive impacts on symbol sign knowledge that has been produced by driver education programs in southwestern New Hampshire.

Recommendations

1. An information program should be established in New Hampshire to educate drivers about symbol signs with special emphasis on older drivers.

2. The driver licensing examinations in New Hampshire should test the symbol signs that have been identified in this study as being critical to the driving task.

3. A uniform graphic representation for the intensity of the hazard or the situation should be developed and incorporated into symbol signs.

4. Word messages should be included with complex symbol signs until driver knowledge improves through training, public information, or familiarity.

5. Conflicting messages, presented through differing types of traffic control devices, should be eliminated in complex traffic situations.

Discussion

The significance of this study was in providing an understanding of driver's knowledge of symbol signs and the basis for improving that knowledge. In relation to other studies on symbol signs reviewed in this report, this study was based on the largest random sample of test subjects. It was also the only study to develop a systematic technique for the evaluation, selection, and inclusion of symbol signs in a test instrument.

A program to improve sign knowledge can be approached in a more selective manner since it is now possible to distinguish between drivers who do and do not know selected signs. By determining the signs that are best known by drivers, and relating this information to demographic variables in the driving population, educational programs can be targeted to selected groups.

The knowledge of symbol signs provides an indicator of the effectiveness of the sign message, which can be defined

as the ability of a message to induce a desired behavior in a driver. Effectiveness is dependent upon the application of the sign, attention value of the graphics, selective use, and a clearly recognizable message. In available research reports, symbol signs are generally considered to be more effective than word message signs. The characteristics that make these signs more effective, however, have not been well defined.

If attention value of the sign is a critical factor in sign knowledge, and a strong logical argument can be made for this case, it must be associated with recognition and recall. Testing effectiveness through attention value will encounter a major source of invalidity in driver discrimination. Discrimination involves the ability of the driver to selectively process stimuli from the environment. An essential part of discrimination entails ignoring irrelevant information or disgarding information once it becomes irrelevant. Assessing attention value in a dynamic format could prove difficult if the test subject drivers employ the process of discrimination effectively.

A more reliable indicator of attention value would be derived from testing signs in a highly structured environment that requires some element of volition on the part of the test subject. The key to such a test would be in defining the possible influences on driver actions from the environment that may supplement the sign message and influence the target volition.

In this study, emphasis was focused on knowledge and understanding of symbol signs rather than detection and identification. Detection and identification serve to answer the question of whether or not the sign was observed in the traffic environment by the driver. Knowledge and understanding, on the other hand, are tested to evaluate whether or not the driver knows the appropriate response in relation to a given sign message. Detection and identification are based on the cognitive processes of rote memory. Knowledge and understanding require higher level thinking processes of an evaluative format, especially when the sign is tested in a dynamic scene.

The studies conducted by Mackie (12), Dewar (4), Drory and Shinar (6), and Roberts (17) relied on driver recall as a critical element of the test process.

The shortcoming though, of testing symbol sign knowledge, with either level of emphasis and in any format, is that neither can guarantee an appropriate response to a traffic situation as the result of the presence of an effective message. The inherent complexity of the driving task dictates otherwise.

The information presented by symbol signs has some of the same shortcomings as word message, diagrammatic, and changeable message signs. This study can support several observations in this respect, though not necessarily in strict empirical terms.

1. The complexity of the graphics of symbol signs is a determining factor in the efficiency of the message presented to the driver. Allen (1) cited graphic complexity as a limitation of signs and the test results of this study supports the assertion. The four signs with the lowest correct response rate (Center Lane Left Turn Only, Left Turn Only, Workers On Road, and Divided Highway Ahead) have the most complex and least specific graphics of the fifteen signs tested.

2. Symbol signs perform an important function by eliminating the need for reading skills, but the requirement that the driver receive accurate information from the sign still exists. More than fifteen percent of the drivers in the study sample received inaccurate information in the test situation on the nine lowest ranked symbol signs. Allen's conclusions on the limitations created by the complexity of the graphics again holds true in this selection of nine symbol signs, with the possible exception of the Merging Traffic and T-Intersection items.

3. The six highest ranking symbol signs in terms of correct response rate all contain features that aid in efficiency of the message and driver knowledge. These consisted of:

A. Well recognized graphic features such as the red prohibition symbol (No Left Turn);

B. The incorporation of a simple word message as an element of the sign (Do Not Enter); or,

C. Traditional symbols that have been used in the traffic environment since well before the adoption of modern symbol signs.

4. Gordon (8) and Roberts (17) reported that the efficiency of intricate graphics tended to degrade in complex situations. The two lowest ranking signs on the correct response rate scale in this study (Center Lane Left Turn Only and No Left Turn) are appropriate examples of this concept. The former contains relatively intricate graphics but a more substantial problem exists in that both fail to accurately mirror the complimentary pavement markings that drivers encounter.

Both signs are applied in complex traffic environments to aid in lane selection and their use is dictated by high vehicular volumes. Complex traffic situations often lead to incorrect lane selection and vehicle position decisions on the part of the driver. In the case of these two signs, the addition of a lane position reference to the graphics may enhance driver decisions by serving as a mirror of the roadway markings. The degradation of symbol sign efficiency, in complex traffic situations, may be the result of the lack of specificity in the symbolic reference rather than the intricacy of the graphics.

5. The reliability of the messages presented by the lowest ranking signs in terms of correct response rate is subject to question. In most cases, the incorrect responses to an item were divided over the three foils,

indicating that the test subjects were developing multiple interpretations of the meaning of the symbol. A requirement for an effective symbol sign is that it present a singular message to all drivers.

6. A drawback of symbol signs, over diagrammatic and changeable message signs, is that in most cases they do not reflect the intensity of the hazard or the situation that the driver may encounter. An approach to overcome this deficiency would be the addition of a uniform graphic representation for the intensity of the situation or hazard to the border of the sign.

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APPENDICES

APPENDIX A

TEST INSTRUMENT AND ANSWER FORM

PLEASE DO NOT WRITE ON THESE PAGES

1. 

THIS SIGN MEANS:

A. NO TURNS
B. LEFT TURNS ALLOWED
C. NO LEFT TURNS ALLOWED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

2. 

THIS SIGN MEANS:

A. THE INDICATED TURN MUST BE MADE
B. NO TURNS ARE ALLOWED
C. THE LANE MAY BE USED TO MAKE A LEFT TURN

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

3. 

THIS SIGN MEANS:

A. KEEP LEFT
B. LANE CLOSED AHEAD
C. VEHICLES APPROACHING ON LEFT

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

4. 

THIS SIGN MEANS:

A. NO PARKING ANYTIME
B. DO NOT ENTER THIS STREET OR ROAD
C. EXIT ONLY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

5. 

THIS SIGN MEANS:

A. DIVIDED HIGHWAY AHEAD
B. LEFT TURNS ONLY AT INTERSECTIONS
C. CENTER LANE FOR LEFT TURNS ONLY

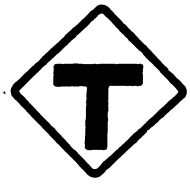
HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

6. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. SLOW AND LOOK FOR RIGHT CURVE
B. WATCH FOR TRAFFIC ON SIDE ROADS
C. PROCEED AT NORMAL SPEED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

7. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PREPARE TO TURN LEFT OR RIGHT
B. DRIVE AT A SAFE SPEED
C. REDUCE SPEED AND DRIVE WITH CARE

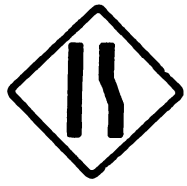
HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

8. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR TRAFFIC ENTERING FROM RIGHT
B. PREPARE TO STOP
C. MERGE WITH TRAFFIC

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

9. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR ON-COMING TRAFFIC
B. MERGE LEFT
C. WATCH FOR LOW SHOULDER

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

10. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. LOOK FOR TWO-WAY TRAFFIC AHEAD
B. MOVE RIGHT TO AVOID AN OBSTRUCTION
C. EXPECT A DIVIDED HIGHWAY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

11. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. LOOK FOR WET SLIPPERY ROAD
B. EXPECT A ROAD FOR CARS ONLY
C. LOOK FOR A SERIES OF CURVES

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

12. 

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. EXPECT ROAD TO NARROW TO 12 FEET 6 INCHES
B. EXPECT LOW CLEARANCE OF 12 FEET 6 INCHES
C. USE PARKING SPACES 12 FEET 6 INCHES

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

13. 

THIS SIGN MEANS:

A. NARROW BRIDGE
B. OBSTRUCTION IN ROAD
C. SOFT SHOULDER

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

14. 

THIS SIGN MEANS:

A. FLAGMAN AHEAD
B. ROAD WORK
C. WORKERS ON ROAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

15. 

THIS SIGN MEANS:

A. TWO-WAY TRAFFIC
B. STOP FOR ON-COMING TRAFFIC
C. DIVIDED ROAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

ANSWER SHEET

1.	A	B	C	YES	NO
2.	A	B	C	YES	NO
3.	A	B	C	YES	NO
4.	A	B	C	YES	NO
5.	A	B	C	YES	NO
6.	A	B	C	YES	NO
7.	A	B	C	YES	NO
8.	A	B	C	YES	NO
9.	A	B	C	YES	NO
10.	A	B	C	YES	NO
11.	A	B	C	YES	NO
12.	A	B	C	YES	NO
13.	A	B	C	YES	NO
14.	A	B	C	YES	NO
15.	A	B	C	YES	NO

APPENDIX B

VALIDITY AND RELIABILITY OF THE TEST INSTRUMENT

APPENDIX B

VALIDITY AND RELIABILITY OF THE TEST INSTRUMENT

Part I--Test Instrument Validity

A fifteen item domain referenced test was developed for this study and the validity and reliability of the instrument was established. Content validity was assessed using the procedure presented by Mussio and Smith in Content Validity: A Procedural Manual. The coefficient of reliability of the instrument was established through a pilot study.

In conducting the content validity assessment, four traffic safety and traffic engineering experts were asked to evaluate symbol signs on the basis of their importance to the driving task. Each symbol sign was ranked on a scale of 1 to 5 (high to low) and the average computed from the four rankings. The fifteen symbol signs with the highest rankings were selected for inclusion in the test instrument as found in Appendix A. The rankings of the fifteen selected items were subjected to statistical analysis using a version of Kuder-Richardson Formula 20. An index of interrater reliability and content validity of r=.979 was established. Details are presented below.

Index of Interrater Reliability and Content Validity

1. Scores and Totals

	TEST ITEMS															
Raters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Rater Totals
#1	1	3	3	1	4	1	3	1	1	1	1	1	1	1	1	24
#2	2	2	3	1	2	1	2	2	2	2	2	2	2	2	2	29
#3	2	2	1	1	1	3	1	2	1	2	1	4	2	3	3	29
#4	1	1	1	1	1	3	3	3	3	3	3	1	3	1	1	29
Item Totals	6	8	8	4	8	8	9	8	7	8	7	8	8	7	7	111
Item Totals^2	36	64	64	16	64	64	81	64	49	64	49	64	64	49	49	841

2. Squares of Scores and Totals

	TEST ITEMS															
Raters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
#1	1	9	9	1	16	1	9	1	1	1	1	1	1	1	1	576
#2	4	4	9	1	4	1	4	4	4	4	4	4	4	4	4	841
#3	4	4	1	1	1	9	1	4	1	4	1	16	4	9	9	841
#4	1	1	1	1	1	9	9	9	9	9	9	1	9	1	1	841
	10	18	20	4	22	20	23	18	15	18	15	22	18	15	15	3099

3. Sum of Squared Scores and Totals

Sum of Test Item Scores^2 = 253
Sum of 15 Test Items Totals^2 = 841
Sum of 4 Rater Totals^2 = 3099
K(number of items) = 15

4. Variances

Sum of Items $= \frac{253}{15} - \frac{841}{15^2} = 13.129$

Total Score $= \frac{3099}{15} - \frac{111^2}{15^2} = 151.84$

5. Interrater Reliability and Index of Content Validity

$$r = \frac{K}{K-1}\left[1 - \frac{V_i^2}{V_t^2}\right] = \frac{15}{14}\left[1 - \frac{13.192}{151.84}\right] = .979$$

The procedural manual prepared for the assessment of content validity in developing the test instrument can be found in Part III of this appendix.

Part II--Test Instrument Reliability

The reliability of the test instrument was established through a pilot study in which the test was administered to a random sample of fifty motor vehicle operator license renewal applicants. Test results were tabulated and subjected to statistical analysis using Kuder-Richardson Formula 21' (K-R21'). A reliability correlation coefficient of r=.945 was obtained. Details are presented below.

The formula for the calculation was as follows:

$$K\text{-}R21' = 1 - \frac{.8M\ (K-M)}{KV^2}\ , \text{ where}$$

K = number of test items = 15

V = variance = 31.7556

M = mean test score = 12.38

$$r = 1 - \frac{[(.8)(12.38)\ \ (15-12.38)]}{[(15)(31.7556)]} = 1 - .0545 = .9455$$

Part III--Content Validity Assessment Manual

CONTENT VALIDITY ASSESSMENT

FOR

A TEST OF NEW HAMPSHIRE DRIVERS' KNOWLEDGE OF SYMBOL SIGNS

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INTRODUCTION

The objective of this assessment is to establish the content validity of a test instrument that will be used to determine drivers' knowledge of selected symbol signs. A secondary purpose is to select a representative sample of sign items, in each of the sign categories, to use in the construction of the instrument.

RESEARCH OBJECTIVES

The purpose of this research is to:

1. Determine drivers' familiarity with various symbol signs.

2. Assess drivers' knowledge of standardized symbol signs that are used as traffic control devices.

3. Distinguish between the effects of the variables of age, sex, driving experience, and formal training on knowledge of symbol signs.

INSTRUCTIONS TO REVIEWERS

Each of the steps in this content validity process is outlined below. Please read through the sequence of steps and then follow each in order. The process employed in this exercise was developed by Mussio and Smith and outlined in CONTENT VALIDITY: A PROCEDURAL MANUAL.

The confidentiality of individual responses is guaranteed and will only be reported as summary data in the final research report. The reviewers should refrain from discussing their assessment with one another during the content validity process as independence is essential to the procedure.

1. Review the description of the knowledge domain that will be evaluated with the instrument being constructed. This is a description of the skills and behaviors that are to be tested in relation to the driving task.

2. Provide an assessment of the content areas which are used to categorize the symbol signs. The categories represent different traffic sign classifications and are widely accepted divisions. In your assessment, you should

answer the following question:

Do the listed content areas comprise relevant categories of symbol signs?

3. Assign a weight to each of the symbol signs as to their importance in the driving task. One (1) represents the highest ranking and five (5) the lowest.

4. Indicate which signs must tested in each category so that there is a sufficient number of items to discriminate between drivers who do and do not have knowledge of the category.

4. Rank each of the selected test items as:

1. Acceptable
2. Acceptable with revision
3. Unacceptable

When assigning a ranking of 2, Acceptable with revision, please indicate the necessary change(s).

5. Please provide comments as you feel appropriate.

6. Upon completion of the review, return the materials promptly. An envelope is provided for your convenience.

DESCRIPTION OF DOMAIN

The driver knowledge to be evaluated consists of:

1. The meaning that is percieved as a result of seeing a symbol sign.

2. The interpretation given to various symbolic messages of signs.

3. The knowledge of information relating to directions, regulations, and conditions presented through sign legends.

CONTENT VALIDITY ASSESSMENT

PART I EVALUATION OF CONTENT AREAS

The content areas defined for this study of knowledge of symbol signs consist of the following sign classifications:

1. Regulatory signs
2. Warning signs
3. Guide signs
4. Information/service signs
5. Construction signs

RATING: (Please indicate with check mark)

____Acceptable

____Acceptable with revisions

____Unacceptable

Comments:

PART II SYMBOL SIGN EVALUATION

RELEVANCY SCALE FOR EVALUATION OF SYMBOL SIGNS

Assign a weight to each of the following symbol signs as to their importance in the performance of the driving task. A range of 1 to 5 has been established with 1 being the highest ranking and 5 being the lowest. Circle the number representing your evaluation of the sign. The following relevancy scale is provided as the basis for the evaluation:

1 The driver must possess knowledge of this sign to perform the driving task.

2

3 Drivers possessing knowledge of this sign should be able to perform the driving task at a better than average level.

4

5 Drivers possessing a knowledge of this sign should be able to perform the driving task at a superior level.

REGULATORY SIGNS

Note: The number following most signs, i.e.(47), is a reference to the listing of the sign in the Manual on Uniform Traffic Control Devices - 1971.

1.	NO RIGHT TURN (39)	1 2 3 4 5
2.	NO LEFT TURN (39)	1 2 3 4 5
3.	NO U TURN (40)	1 2 3 4 5
4.	MANDATORY MOVEMENT (41)	1 2 3 4 5
5.	OPTIONAL MOVEMENT (41)	1 2 3 4 5
6.	KEEP RIGHT (45)	1 2 3 4 5

7.	KEEP LEFT (46)	1	2	3	4	5
8.	DO NOT ENTER (47)	1	2	3	4	5
9.	NO TRUCKS (48)	1	2	3	4	5
10.	NO BICYCLES (49)	1	2	3	4	5
11.	NO PARKING	1	2	3	4	5
12.	CENTER LANE LEFT TURN ONLY	1	2	3	4	5

WARNING SIGNS

13.	CURVE (66)	1	2	3	4	5
14.	REVERSE TURN (66)	1	2	3	4	5
15.	WINDING ROAD (66)	1	2	3	4	5
16.	LARGE ARROW (68)	1	2	3	4	5
17.	CROSS ROAD (68)	1	2	3	4	5
18.	SIDE ROAD (69)	1	2	3	4	5
19.	T SYMBOL (69)	1	2	3	4	5
20.	Y SYMBOL (69)	1	2	3	4	5
21.	SIGNAL AHEAD (71)	1	2	3	4	5
22.	MERGE (72)	1	2	3	4	5
23.	RIGHT LANE ENDS (72)	1	2	3	4	5
24.	DIVIDED HIGHWAY (73)	1	2	3	4	5
25.	DIVIDED HIGHWAY ENDS (74)	1	2	3	4	5
26.	TWO-WAY TRAFFIC (75)	1	2	3	4	5
27.	HILL (75)	1	2	3	4	5
28.	SLIPPERY WHEN WET (77)	1	2	3	4	5
29.	BICYCLE CROSSING (78)	1	2	3	4	5
30.	PEDESTRIAN CROSSING (79)	1	2	3	4	5

31.	DEER CROSSING (79)	1	2	3	4	5
32.	FARM MACHINERY (79)	1	2	3	4	5
33.	DOUBLE ARROW (80)	1	2	3	4	5
34.	LOW CLEARANCE (80)	1	2	3	4	5
35.	SCHOOL ADVANCE (327)	1	2	3	4	5
36.	SCHOOL CROSSING (327)	1	2	3	4	5
37.	STOP AHEAD	1	2	3	4	5
38.	YIELD AHEAD	1	2	3	4	5

GUIDE SIGNS

39.	ADVANCE TURN ARROW (96)	1	2	3	4	5
40.	DIRECTIONAL ARROW (96)	1	2	3	4	5

INFORMATION/SERVICE SIGNS

41.	PICNIC TABLE (106)	1	2	3	4	5
42.	TELEPHONE (109)	1	2	3	4	5
43.	HOSPITAL (109)	1	2	3	4	5
44.	CAMPING (110)	1	2	3	4	5
45.	BIKE ROUTE (111)	1	2	3	4	5
46.	HIKING TRAIL (112)	1	2	3	4	5
47.	RESTAURANT	1	2	3	4	5
48.	SERVICE STATION	1	2	3	4	5
49.	LODGING	1	2	3	4	5

CONSTRUCTION SIGNS

Note: Construction signs are referenced in Work Zone Traffic Control - April 1988, published by U.S. DOT/FHA.

50.	ADVANCE FLAGGER (6B-20)	1	2	3	4	5
51.	NARROW BRIDGE (6B-22)	1	2	3	4	5
52.	PAVEMENT ENDS (6B-22)	1	2	3	4	5
53.	WORKER AHEAD (6B-21)	1	2	3	4	5
54.	TWO-WAY TRAFFIC (6B-21)	1	2	3	4	5
55.	RIGHT LANE ENDS	1	2	3	4	5

PART III SELECTION OF SIGNS TO BE TESTED

Return to PART II and circle the number of each sign which must be tested in order to discriminate between drivers who do and those who do not have a knowledge of the signs within the categories. Select the MINIMUM number of signs necessary to evaluate the drivers' knowledge in this domain.

PART IV RANKING OF SELECTED TEST ITEMS

Provide an evaluation of the test items corresponding to the signs circled as requested in PART III. Test items relating to signs that were not circled in PART III do not need to be evaluated.

Evaluate each of the test items using the following scale:

1. Acceptable

2. Acceptable with revisions

3. Unacceptable

The necessary revisions must be listed when ranking number 2 is assigned.

TEST ITEMS

1. 

NO RIGHT TURN
THIS SIGN MEANS:

A. NO TURNS
*B. NO RIGHT TURN
C. NO RIGHT TURN ON RED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

2. 

NO LEFT TURN
THIS SIGN MEANS:

A. NO TURNS
B. LEFT TURNS PERMITTED
*C. NO LEFT TURN

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

3. 

NO U TURN
THIS SIGN MEANS:

A. NO TURN ON RED
*B. NO U TURN
C. U TURNS PERMITTED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

4. 

MANDATORY MOVEMENT
THIS SIGN MEANS:

*A. THE INDICATED TURN MUST BE MADE
B. NO TURNS ARE PERMITTED
C. THE LANE MAY BE USED TO MAKE A LEFT TURN

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

5. 

OPTIONAL MOVEMENT
THIS SIGN MEANS:

A. THE ROAD DIVIDES AHEAD
B. TRAFFIC MUST TURN LEFT
*C. THE LANE IS FOR LEFT TURNS OR THROUGH TRAFFIC

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

6. 

KEEP RIGHT
THIS SIGN MEANS:

A. LANE CLOSED AHEAD
*B. KEEP RIGHT OF AN OBSTRUCTION
C. TWO WAY TRAFFIC

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

7. 

KEEP LEFT
THIS SIGN MEANS:

*A. KEEP LEFT OF AN OBSTRUCTION
B. LANE CLOSED AHEAD
C. VEHICLES APPROACHING ON LEFT

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

8. 

DO NOT ENTER
THIS SIGN MEANS:

A. NO PARKING ANYTIME
+B. DO NOT ENTER THIS STREET OR ROAD
C. EXIT ONLY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

9. 

NO TRUCKS
THIS SIGN MEANS:

A. TRUCKS PERMITTED ON STREETS AND ROADS
B. TRUCKS TURNING AT INTERSECTION
*C. NO TRUCKS ALLOWED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

10. 

NO BICYCLES
THIS SIGN MEANS:

*A. BICYCLE TRAFFIC PROHIBITED
B. BICYCLE CROSSING AHEAD
C. LANE FOR BICYCLES ONLY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

11. 

NO PARKING
THIS SIGN MEANS:

A. PEDESTRIAN CROSSING PROHIBITED
*B. NO PARKING
C. NO PASSING

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

12. 

CENTER LANE LEFT TURN ONLY
THIS SIGN MEANS:

A. DIVIDED HIGHWAY AHEAD
B. LEFT TURNS ONLY AT INTERSECTIONS
*C. CENTER LANE FOR LEFT TURNS ONLY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

WARNING SIGNS

13. 

CURVE
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. SLOW AND PREPARE FOR A CURVE TO THE RIGHT
B. WATCH FOR TRAFFIC ON SIDE ROADS
C. PROCEED AT A NORMAL SPEED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

14. 

REVERSE TURN
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. EXPECT A DETOUR IN THE ROAD
*B. PREPARE FOR RIGHT CURVE THEN LEFT CURVE
C. STOP, THEN PROCEED WITH CAUTION

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

15. 

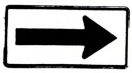
WINDING ROAD
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PROCEED AT A NORMAL SPEED
B. EXPECT A SERIES OF HILLS IN THE ROAD
*C. EXPECT A SERIES OF CURVES IN THE ROAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

16. LARGE ARROW



UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. SLOW AND PREPARE TO MAKE A SHARP RIGHT TURN
B. EXPECT A SHARP LEFT TURN
C. EXPECT A CLOSED LANE AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

17. CROSS ROAD

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. EXPECT A DIVIDED HIGHWAY
*B. WATCH FOR VEHICLES APPROCHING ON CROSSROAD
C. PREPARE TO MAKE A SERIES OF TURNS

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

18. SIDE ROAD

UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PREPARE TO MAKE A LEFT TURN
B. STOP FOR ON-COMING TRAFFIC
*C. WATCH FOR VEHICLES APPROACHING ON SIDE ROAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

19. 

T SYMBOL
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. PREPARE TO TURN LEFT OR RIGHT
B. PROCEED AT A NORMAL RATE OF SPEED
C. REDUCE SPEED AND PROCEED WITH CAUTION

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

20. 

Y SYMBOL
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. SLOW AND PREPARE FOR A SERIES OF CURVES
*B. PREPARE TO TURN LEFT OR RIGHT
C. STOP FOR ON-COMING TRAFFIC

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

21. 

SIGNAL AHEAD
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PROCEED AT A NORMAL SPEED
B. SLOW AND PREPARE TO MAKE A RIGHT TURN
*C. PREPARE TO STOP IF SIGNAL IS RED

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

22. 

MERGE
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. WATCH FOR TRAFFIC ENTERING FROM RIGHT
B. SLOW AND PREPARE TO STOP
C. PREPARE TO MERGE WITH TRAFFIC

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

23. 

RIGHT LANE ENDS
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR ON-COMING TRAFFIC
*B. MERGE LEFT IF TRAVELLING IN RIGHT LANE
C. PREPARE FOR A SERIES OF CURVES

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

24. 

DIVIDED HIGHWAY
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PREPARE FOR TWO-WAY TRAFFIC AHEAD
B. MOVE RIGHT TO AVOID A HAZARD
*C. EXPECT A DIVIDED HIGHWAY AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

25. 

DIVIDED HIGHWAY ENDS
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. EXPECT THE END OF A DIVIDED HIGHWAY
B. MOVE RIGHT TO AVOID A HAZARD
C. EXPECT A DIVIDED HIGHWAY AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

26. 

TWO-WAY TRAFFIC
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PREPARE FOR A DIVIDED ROADWAY AHEAD
*B. EXPECT A TWO-WAY ROADWAY AHEAD
C. WATCH FOR MERGING TRAFFIC

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

27. 

HILL
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR TRUCKS CROSSING AHEAD
B. WATCH FOR STOPPED VEHICLES
*C. REDUCE SPEED AND PREPARE FOR A DOWN-GRADE

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

28. 

SLIPPERY WHEN WET
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. PREPARE FOR SLIPPERY ROAD IF SURFACE IS WET
B. EXPECT A HIGHWAY FOR CARS ONLY
C. REDUCE SPEED AND PREPARE FOR A SERIES OF TURNS

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

29. 

BICYCLE CROSSING
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. KEEP OUT OF BICYCLE LANE
*B. WATCH FOR BICYCLE CROSSING OR TRAFFIC
C. YIELD RIGHT OF WAY TO BICYCLES

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

30. 

PEDESTRIAN CROSSING
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR SCHOOL CROSSING AHEAD
B. HITCH HIKING PROHIBITED
*C. WATCH FOR PEDESTRIAN CROSSING AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

31. 

DEER CROSSING
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. WATCH FOR DEER CROSSING THE ROADWAY
B. WATCH FOR CATTLE CROSSING AHEAD
C. WATCH FOR WILDLIFE PRESERVE AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

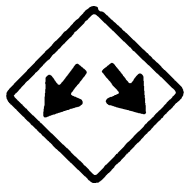
RANKING: 1 2 3
COMMENTS:

32. 

FARM MACHINERY
A. WATCH FOR MAINTENANCE WORK AHEAD
B. PREPARE TO STOP
*C. WATCH FOR FARM MACHINERY ON ROADWAY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

33. 

DOUBLE ARROW
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. PREPARE TO PASS ON EITHER SIDE OF A HAZARD
B. KEEP RIGHT
C. REDUCE SPEED AND PREPARE TO STOP

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

34. 

LOW CLEARANCE
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. EXPECT PAVEMENT TO NARROW TO 12 FEET 6 INCHES
*B. EXPECT A LOW CLEARANCE OF 12 FEET 6 INCHES
C. USE PARKING SPACES 12 FEET 6 INCHES LONG

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

35. 

SCHOOL ADVANCE
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR CROSSING FOR THE BLIND
B. PREPARE TO ENTER A HEAVILY POPULATED AREA
*C. PREPARE TO ENTER A SCHOOL ZONE

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

36. 

SCHOOL CROSSING
UPON SEEING THIS SIGN A DRIVER SHOULD:

*A. WATCH FOR CHILDREN CROSSING THE STREET
B. WATCH FOR A CROSSING FOR THE BLIND
C. PREPARE TO ENTER A PEDESTRIAN CROSSING AREA

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

37. STOP AHEAD
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. EXPECT ON-COMING TRAFFIC TO STOP AT INTERSECTION
*B. REDUCE SPEED AND PREPARE TO STOP
C. NOT TURN RIGHT AT INTERSECTION

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

38. YIELD AHEAD
UPON SEEING THIS SIGN A DRIVER SHOULD:

A. NOT TURN LEFT AT INTERSECTION
B. EXPECT ON-COMING TRAFFIC TO STOP
*C. REDUCE SPEED AND PREPARE TO STOP IF NECESSARY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

GUIDE SIGNS

39. ADVANCE TURN ARROW
THIS SIGN MEANS:

*A. THE ROUTE BEING TRAVELLED TURNS LEFT AHEAD
B. CENTER LANE LEFT TURN ONLY
C. ALL TRAFFIC MUST TURN LEFT

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

40. DIRECTIONAL ARROW

THIS SIGN MEANS:

A. NO TURNS PERMITTED
*B. THE ROUTE BEING FOLLOWED PROCEEDS STRAIGHT
C. ALL TRAFFIC MUST GO STRAIGHT

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

INFORMATION SERVICE SIGNS

41. PICNIC TABLE

THIS SIGN MEANS:

A. REST AREA
B. CAMPING AREA AHEAD
*C. ROADSIDE PICNIC TABLE AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

42. TELEPHONE

THIS SIGN MEANS:

*A. ROADSIDE TELEPHONE AHEAD
B. EMERGENCY SERVICE AREA
C. END OF EMERGENCY TELEPHONE NETWORK

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

43. 

HOSPITAL
THIS SIGN MEANS:

A. HOTEL PARKING
*B. DIRECTION TO HOSPITAL
C. LODGING INFORMATION

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

44. 

CAMPING
THIS SIGN MEANS:

A. LODGING INFORMATION
B. REST AREA
*C. CAMPING AREA

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

45. 

BIKE ROUTE
THIS SIGN MEANS:

*A. BICYCLE ROUTE
B. NO BICYCLES
C. BICYCLE CROSSING AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

46. 

HIKING TRAIL
THIS SIGN MEANS:

A. PEDESTRIAN CROSSING
*B. HIKING TRAIL
C. SCHOOL ZONE

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

47. 

RESTAURANT
THIS SIGN MEANS:

A. LODGING INFORMATION
B. PICNIC AREA
*C. RESTAURANT OR DINING FACILITY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

48. 

SERVICE STATION
THIS SIGN MEANS:

*A. SERVICE STATION
B. REST AREA
C. TRAVEL INFORMATION

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

49. 

LODGING
THIS SIGN MEANS:

A. REST AREA
*B. LODGING OR MOTEL SERVICES
C. TRAVEL INFORMATION

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

CONSTRUCTION SIGNS

50. 

ADVANCE FLAGGER
THIS SIGN MEANS:

A. MEN WORKING
B. DETOUR AHEAD
*C. FLAGMAN AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

51. 

NARROW BRIDGE
THIS SIGN MEANS:

*A. NARROW BRIDGE AHEAD
B. OBSTRUCTION IN ROADWAY
C. SOFT SHOULDER

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

52. PAVEMENT ENDS

THIS SIGN MEANS:

A. BUMP
*B. PAVEMENT ENDS
C. ROAD NARROWS

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

53. WORKER

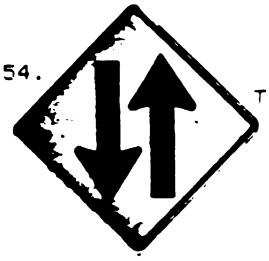
THIS SIGN MEANS:

A. FLAGMAN AHEAD
B. ROAD MACHINERY AHEAD
*C. WORKERS IN ROADWAY

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

54. TWO-WAY TRAFFIC



THIS SIGN MEANS:

*A. TWO-WAY TRAFFIC AHEAD
B. STOP FOR ON-COMING TRAFFIC
C. DIVIDED HIGHWAY AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3
COMMENTS:

55. RIGHT LANE ENDS
THIS SIGN MEANS:

A. NO TURNS
*B. ROAD NARROWS FROM RIGHT
C. TWO-WAY ROADWAY AHEAD

HAVE YOU EVER SEEN THIS SIGN WHILE DRIVING? YES NO

RANKING: 1 2 3

COMMENTS:

APPENDIX C

READABILITY ASSESSMENT OF THE TEST INSTRUMENT

Keene State College
Inter-Department Memorandum

To: George Bower Date: October 20, 1982

From: Glenna Mize, Ph.D.
Reading Specialist - Safety Center

Using the Frye Readability Formula attached, the estimated average reading difficulty of the three-page form is 4.2.

Page	Sentences	Syllables	Estimated Grade Level
1	9	133	5.3
2	8	117	3
3	8	115	3
4	7.5	125	5.5
			$11.5 \div 4 = 4.2$

The addition of the sign should reduce the reading difficulty even more because of the visual representation.

GJM:jb

APPENDIX D

ANALYSIS TABLES OF THE TEST VARIABLES

Table D1

Mean Scores of Test Subjects by Age and Sex

BREAKDOWN OF AGE AND SEX

ACROSS - AGE

DOWN - SEX

	Age Groups							
	16-19	20-29	30-39	40-49	50-59	60-69	70+	TOTAL
FEMALE								
MEAN	85.000	78.000	82.686	77.706	63.667	64.700	71.000 :	76.404
STDDEV	8.485	19.494	9.489	11.537	12.698	16.125	17.088 :	15.538
N	4	30	35	17	15	10	3 :	114
MALE								
MEAN	87.000	82.880	84.222	82.650	75.063	77.400	77.667 :	81.571
STDDEV	.000	11.319	11.804	15.618	20.407	11.327	4.041 :	14.087
N	2	25	27	20	16	5	3 :	98
TOTAL								
MEAN	85.667	80.218	83.355	80.378	69.548	68.933	74.333 :	78.792
STDDEV	6.653	16.341	10.496	13.933	17.804	15.563	11.690 :	15.073
N	6	55	62	37	31	15	6 :	212

Table D2

Mean Scores of Test Subjects by Age and Training

ACROSS - AGE

DOWN -TRAINING - DRIVER EDUCATION

	AGE GROUPS							
	16-19	20-29	30-39	40-49	50-59	60-69	70+	TOTAL
NO TRAINING	0	76.333	81.708	77.739	69.920	68.933	78.600	: 75.356
	0	27.717	12.376	15.789	17.888	15.563	5.857	: 16.994
	0	9	24	23	25	15	5	: 101
TRAINING	85.667	80.978	84.395	84.714	68.000	0	53.000	: 81.919
	6.653	13.425	9.140	9.118	19.037	0	.000	: 12.352
	6	46	38	14	6	0	1	: 111
TOTAL	85.667	80.218	83.355	80.378	69.548	68.933	74.333	: 78.792
	6.653	16.341	10.496	13.933	17.804	15.563	11.690	: 15.073
	6	55	62	37	31	15	6	: 212

Table D3

Mean Scores of Test Subjects by Driving Experience and Sex

BREAKDOWN OF EXPERIENCE AND SEX

ACROSS - EXPERIENCE

DOWN - SEX

	DRIVING EXPERIENCE CLASSIFICATIONS (MILES PER WEEK)								
	1.	2.	3.	4.	5.	6.	7.	8.	TOTAL
FEMALE									
MEAN	73.500	69.400	77.279	75.214	78.211	80.700	73.500	:	76.404
STDDEV	9.192	16.426	13.539	20.565	15.175	8.015	9.192	:	15.538
N	2	10	43	28	19	10	2	0 :	114
MALE									
MEAN		66.667	77.091	81.688	80.273	80.700	89.000	87.765 :	81.571
STDDEV		34.962	17.207	13.446	12.464	12.374	3.464	10.680 :	14.087
N	0	3	11	32	22	10	3	17 :	98
TOTAL	73.500	68.769	77.241	78.667	79.317	80.700	82.800	87.765 :	78.792
	9.192	20.187	14.182	17.296	13.648	10.147	9.960	10.680 :	15.073
	2	13	54	60	41	20	5	17 :	212

Driving Experience Classifications in Miles per Week

1. 0 2. 1-20

2. 20-50 3. 50-100

5. 100-200 6. 200-300

7. 300-400 8. 400+

Table D4

Mean Scores of Test Subjects by Experience and Training

BREAKDOWN OF EXPERIENCE AND TRAINING

ACROSS - EXPERIENCE

DOWN - TRAINING - DRIVER EDUCATION

	EXPERIENCE CLASSIFICATIONS IN MILES PER WEEK*								
	1.	2.	3.	4.	5.	6.	7.	8.	TOTAL
NO TRAINING									
MEAN	67.000	60.200	75.333	73.971	75.643	77.778	80.250	84.000	: 75.356
STDDEV	.000	22.163	14.893	20.126	17.310	12.091	9.430	10.187	: 16.994
N	1	5	24	34	14	9	4	10	: 101
TRAINING									
MEAN	80.000	74.125	78.767	84.808	81.222	83.091	93.000	93.143	: 81.919
STDDEV	.000	18.240	13.647	10.104	11.212	8.043	.000	9.547	: 12.352
N	1	8	30	26	27	11	1	7	: 111
TOTAL									
MEAN	73.500	68.769	77.241	78.667	79.317	80.700	82.800	87.765	: 78.792
STDDEV	9.192	20.187	14.182	17.296	13.648	10.147	9.960	10.680	: 15.073
N	2	13	54	60	41	20	5	17	: 212

*Driving Experience Classifications in Miles per Week

1. 0 2. 1-20
2. 20-50 3. 50-100
5. 100-200 6. 200-300
7. 300-400 8. 400+

Table D5

Mean Scores of Test Subjects by Sex and Training

BREAKDOWN OF SEX AND TRAINING
ACROSS - SEX
DOWN - TRAINING - DRIVER EDUCATION

	FEMALE	MALE	
NO TRAINING			
MEAN	72.865	78.000	75.356
STDDEV	17.255	16.476	16.994
N	52	49	101
TRAINING			
MEAN	79.371	85.143	81.919
SDTDEV	13.368	10.176	12.352
N	62	49	111
TOTAL			
MEAN	76.404	81.571	78.792
STDDEV	15.538	14.087	15.073
N	114	98	212

Table D6

Correlation Matrix for Test Variables

NUMBER OF CASES = 212

CORRELATION, SIGNIFICANCE

	KNOWLEDGE	AGE	SEX	TRAINING
AGE	-.272 .000			
SEX	.171 .006	.022 .374		
TRAINING	.218 .001	-.541 .000	-.044 .263	
EXPERIENCE	.226 .000	-.047 .250	.393 .000	-.059 .198

APPENDIX E

BREAKDOWN OF TEST ITEM RESPONSES

Table E-1

Item 1: No Left Turn

1. THIS SIGN MEANS:

A. NO TURNS
B. LEFT TURNS ALLOWED
C. NO LEFT TURNS ALLOWED

RESPONSE	N	TOT %	NM %	CUM %	
A	18	8.5	8.6	8.6	
B	10	4.7	4.8	13.4	
C	181	85.4	86.6	100.0	CORRECT
0	3	1.4	NA	NA	NO RESPONSE

RESPONSES TO ITEM 1 = 209

"Have you ever seen this sign while driving?"

YES: 187 (88.7%) NO: 22 NO RESPONSE: 3

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-2

Item 2: Right Turn Only

2. THIS SIGN MEANS:

A. THE INDICATED TURN MUST BE MADE
B. NO TURNS ARE ALLOWED
C. THE LANE MAY BE USED TO MAKE A LEFT TURN

RESPONSE	N	TOT %	NM %	CUM %	LABEL
A	126	59.4	60.0	60.0	CORRECT
B	1	.5	.5	60.5	
C	83	39.2	39.5	100.0	
0	2	.9	NA	NA	NO RESPONSE

RESPONSES TO ITEM 2 = 210

"Have you ever seen this sign while driving?"

YES: 199 (93.8%) NO: 9 NO RESPONSE: 4

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-3

Item 3: Keep Left

3. THIS SIGN MEANS:

A. KEEP LEFT
B. LANE CLOSED AHEAD
C. VEHICLE APPROACHING ON LEFT

RESPONSE	N	TOT %	NM %	CUM %	LABEL
A	178	84.0	87.7	87.7	CORRECT
B	20	9.4	9.9	97.5	
C	5	2.4	2.5	100.0	
0	9	4.2M	NA	NA	NO RESPONSE

RESPONSES TO ITEM 3 = 203

"Have you ever seen this sign while driving?"

YES: 128 (63.4%) NO: 79 NO RESPONSE: 5

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-4

Item 4: Do Not Enter

4. THIS SIGN MEANS:

A. NO PARKING ANYTIME
B. DO NOT ENTER THIS STREET OR ROAD
C. EXIT ONLY

RESPONSE	N	TOT %	NM %	CUM %	
A	5	2.4	2.4	2.4	
B	200	94.3	95.2	97.6	CORRECT
C	5	2.4	2.4	100.0	
0M	2M	.9M	NA	NA	NO RESPONSE

RESPONSES TO ITEM 4 = 210

"Have you ever seen this sign while driving?"

YES: 205 (96.7%) NO: 4 NO RESPONSE: 3

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-5

Item 5: Center Lane Left Turn Only

5. THIS SIGN MEANS:

A. DIVIDED HIGHWAY AHEAD
B. LEFT TURNS ONLY AT INTERSECTION
C. CENTER LANE FOR LEFT TURNS ONLY

RESPONSE	N	TOT %	NM %	CUM %	
A	23	10.8	12.4	12.4	
B	102	48.1	54.8	67.2	
C	61	28.8	32.8	100.0	CORRECT
0M	26M	12.3M	NA	NA	NO RESPONSE

RESPONSES TO ITEM 5 = 186

"Have you ever seen this sign while driving?"

YES: 49 (23.1%) NO: 161 NO RESPONSE: 2

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-6

Item 6: Right Curve

6. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. SLOW AND LOOK FOR RIGHT CURVE
B. WATCH FOR TRAFFIC ON SIDE ROADS
C. PROCEED AT NORMAL SPEED

RESPONSE	N	TOT %	NM %	CUM %	
A	200	94.3	94.3	94.3	CORRECT
B	3	1.4	1.4	95.8	
C	9	4.2	4.2	100.0	

RESPONSES TO ITEM 6 = 212

"Have you ever seen this sign while driving?"

YES: 206 (97.2%) NO: 6 NO RESPONSE: 0

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-7

Item 7: T Intersection

7. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. PREPARE TO TURN LEFT OR RIGHT
B. DRIVE AT A SAFE SPEED
C. REDUCE SPEED AND DRIVE WITH CARE

RESPONSE	N	TOT %	NM %	CUM %	
A	170	80.2	86.3	86.3	CORRECT
B	4	1.9	2.0	88.3	
C	23	10.8	11.7	100.0	
0	15	7.1	NA	NA	NO RESPONSE

RESPONSES TO ITEM 7 = 197

"Have you ever seen this sign while driving?"

YES: 117 (55.2%) NO: 93 NO RESPONSE: 2

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-8

Item 8: Merging Traffic

8. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR TRAFFIC ENTERING FROM RIGHT
B. PREPARE TO STOP
C. MERGE WITH TRAFFIC

RESPONSE	N	TOT %	NM %	CUM %	
A	175	82.5	83.7	83.7	CORRECT
B	1	.5	.5	84.2	
C	33	15.6	15.8	100.0	
0	3	1.4	NA	NA	NO RESPONSE

RESPONSES TO ITEM 8 = 209

"Have you ever seen this sign while driving?"

YES: 173 (81.6%) NO: 35 NO RESPONSE: 4

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-9

Item 9: Merge Left

9. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. WATCH FOR ONCOMING TRAFFIC
B. MERGE LEFT
C. WATCH FOR LOW SHOULDER

RESPONSE	N	TOT %	NM %	CUM %	
A	31	14.6	15.2	15.2	
B	152	71.7	74.5	89.7	CORRECT
C	21	9.9	10.3	100.0	
0	8	3.8	NA	NA	NO RESPONSE

RESPONSES TO ITEM 9 = 204

"Have you ever seen this sign while driving?"

YES: 149 (70.3%) NO: 57 NO RESPONSE: 6

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-10

Item 10: Divided Highway Ahead

10. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. LOOK FOR TWO WAY TRAFFIC AHEAD
B. MOVE RIGHT TO AVOID OBSTRUCTION
C. EXPECT A DIVIDED HIGHWAY

RESPONSE	N	TOT %	NM %	CUM %	
A	20	9.4	10.0	10.0	
B	30	14.2	15.0	25.0	
C	150	70.8	75.0	100.0	CORRECT
0	12	5.7	NA	NA	NO RESPONSE

RESPONSES TO ITEM 10 = 200

"Have you ever seen this sign while driving?"

YES: 129 (60.8%) NO: 78 NO RESPONSE: 5

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-11

Item 11: Slippery Road

11. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. LOOK FOR WET SLIPPERY ROAD
B. EXPECT A ROAD FOR CARS ONLY
C. LOOK FOR A SERIES OF CURVES

RESPONSE	N	TOT %	NM %	CUM %	
A	193	91.0	92.8	92.8	CORRECT
B	1	.5	.5	93.3	
C	14	6.6	6.7	100.0	
0	4	1.9	NA	NA	NO RESPONSE

RESPONSES TO ITEM 11 = 208

"Have you ever seen this sign while driving?"

YES: 178 (84.0%) NO: 21 NO RESPONSE: 4

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-12

Item 12: Low Clearance - 12 Feet 6 Inches

12. UPON SEEING THIS SIGN A DRIVER SHOULD:

A. EXPECT ROAD TO NARROW TO 12 FEET 6 INCHES
B. EXPECT LOW CLEARANCE OF 12 FEET 6 INCHES
C. USE PARKING SPACES 12 FEET 6 INCHES

RESPONSE	N	TOT %	NM %	CUM %	
A	6	2.8	2.9	2.9	
B	202	95.3	97.1	100.0	CORRECT
0	4	1.9	NA	NA	NO RESPONSE

RESPONSES TO ITEM 12 = 208

"Have you ever seen this sign while driving?"

YES: 191 (90.1%) NO: 18 NO RESPONSE: 3

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-13

Item 13: Narrow Bridge

13. THIS SIGN MEANS:

A. NARROW BRIDGE
B. OBSTRUCTION IN ROAD
C. SOFT SHOULDER

RESPONSE	N	TOT %	NM %	CUM %	
A	176	83.0	92.6	92.6	CORRECT
B	7	3.3	3.7	96.3	
C	7	3.3	3.7	100.0	
0	22	10.4	NA	NA	NO RESPONSE

RESPONSES TO ITEM 13 = 190

"Have you ever seen this sign while driving?"

YES: 48 (22.6%) NO: 158 NO RESPONSE: 6

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-14

Item 14: Workers On Road

14. THIS SIGN MEANS:

A. FLAGMAN AHEAD
B. ROAD WORK
C. WORKERS ON ROAD

RESPONSE	N	TOT %	NM %	CUM %	
A	33	15.6	16.2	16.2	
B	39	18.4	19.1	35.3	
C	132	62.3	64.7	100.0	CORRECT
0	8	3.8	NA	NA	NO RESPONSE

RESPONSES TO ITEM 14 = 204

"Have you ever seen this sign while driving?"

YES: 98 (46.2%) NO: 109 NO RESPONSE: 5

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %

Table E-15

Item 15: Two Way Traffic

15. THIS SIGN MEANS:

A. TWO-WAY TRAFFIC
B. STOP FOR ON-COMING TRAFFIC
C. DIVIDED ROAD

RESPONSE	N	TOT %	NM %	CUM %	
A	208	98.1	98.1	98.1	CORRECT
C	4	1.9	1.9	100.0	

RESPONSES TO ITEM 14 = 212

"Have you ever seen this sign while driving?"

YES: 176 (83.0%) NO: 31 NO RESPONSE: 5

N = Number of Responses
TOT % = % of All Responses
NM% = % of Valid Responses
CUM % = Cumulative %