THE DEVELOPMENT AND TESTING OF A SIMULATED DYNAMIC DRIVING HAZARD PERCEPTION TEST

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ABSTRACT

THE DEVELOPMENT AND TESTING OF A SIMULATED DYNAMIC DRIVING HAZARD PERCEPTION TEST

By

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The most important elements of the driving task are those processes related to perception. Driver perception is an all inclusive term, and the process, because of its complexity, is difficult to determine and measure. One facet of driver perception that can be measured is the recognition of driving hazards.

The primary purpose of this thesis was to develop an instrument to measure a phase of that process called dynamic driver perception, primarily that of driving hazard recognition. A secondary purpose was to determine how drivers respond to the instrument.

To accomplish these purposes two tasks were undertaken: (1) a motion picture film sequence instrument was developed to be used as a test in evaluating the ability of drivers to recognize driving hazards, and (2) a means to evaluate the manner in which drivers responded to the instrument was accomplished.

The instrument consisted of fifteen, 16mm film clips or sequences depicting various types of driving hazards called the Simulated Dynamic Driving Hazard Perception Test (SDDHPT) which was developed from six driving simulation films provided by Allstate Insurance Company. Experts representative of traffic safety disciplines confirmed the hazards and established limits by which subjects' response time was measured by means of a specially developed counter attached to a motion picture projector.

The sample consisted of fifty-eight drivers from the Lansing, Michigan area; twenty-nine were license renewal applicants, who had no accidents or violations on their driving records. The other twenty-nine were drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent (chargeable) accidents within the past two years.

The results of the analysis of the data revealed:

1. When measured only by recognition of hazards a t-test of significance indicated no significant difference at the .05 level between the mean score of the renewal and improvement groups.

2. When measured by recognition of the hazards within the time set and validated by traffic safety experts a t-test of significance indicated no significant difference at the .05 level between the mean scores of the R and I Groups.

3. Findings from each sequence indicate that except for sequence 2 there was no significant difference with respect to the film location at which the two groups identified the hazard.

4. With respect to the identification of the hazard within the experts' limit there was no significant difference between groups in all sequences.

5. The majority of subjects in Groups R and I were unable to identify the hazards confirmed by the experts in six of twelve sequences.

6. Recognition of hazards within the experts' limit for both subject groups was poor as defined by the experts.

Recommendations for further research:

1. A study should be undertaken to determine if persons identified as problem drivers differ in visual perception capability from recognized safe commercial drivers as measured by the SDDHPT.

2. Research should be undertaken in which a correlation of the SDDHPT with another measure of visual perceptual capabilities is made.

3. A replication of this investigation using another visual perceptual measure should be done.

4. Research should be instituted in which a correlation of the SDDHPT with the Michigan State University

Driver Performance Measurement instrument should be evaluated.

5. A correlation of the SDDHPT with the Project METER (Machine, Examination, Teaching, Evaluation and Reeducation) should be conducted.

6. To establish norms applicable to the general population, large groups of matched subjects should be tested by the SDDHPT.

THE DEVELOPMENT AND TESTING OF A SIMULATED DYNAMIC DRIVING HAZARD PERCEPTION TEST

By

Raymond Olaf Swensen

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THE PROBLEM

Introduction

". . . a universally agreed-upon definition of perception simply does not exist, . . . a working definition of perception can be considered as an awareness of our environment."[1]

The literature related to perception tends to be theoretical in nature because some theories account for limited areas of perceptual phenomena while others have been extended with the intent to integrate all of psychology. Beyond this, additional theories have stimulated new research with the hope of revealing new perceptual relationships.[2]

"In the field of perception, there are many examples of innate perceptual responses in lower forms."[3]

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[1]Herschel W. Leibowitz, Visual Perception (New York: The Macmillan Company, 1969), Preface.

[2]Daniel J. Weintraub and Edward L. Walker, Perception (Belmont, California: Brooks/Cole Publishing Company, 1966), p. 4.

[3]Leibowitz, op. cit., p. 10.

"As we ascend the phylogenetic scale, learning becomes increasingly important, and instinctive behavior is progressively less conspicuous."[4]

There is no doubt that perception is learned for " [p]erception would be of little use to the organism if it were not modifiable by experience."[5]

> . . . Attention, or selective perception, is an extremely important concept in the study of perception, because it determines what we are aware of at the moment.
>
> The appropriateness of our attention may at times be rather important, if not critical, to our adjustment. The student in class who is thinking about something other than the lecture topic may as well not be in class. The driver whose attention wanders from the road in front of him may become involved in an accident.[6]

The driver whose attitude or mood is anxious or critical could very well incorrectly perceive a truly dangerous driving hazard.[7]

According to James E. Aaron and Marland K. Strasser in Driver and Traffic Safety Education, "Patterns of behavior must be the result of selecting correct stimuli from the environment and discarding those that are incorrect."[8]

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[4]Ibid., p. 16.

[5]Ibid., p. 27.

[6]Ibid., p. 28.

[7]Ibid., p. 96.

[8]James E. Aaron and Marland K. Strasser, Driver and Traffic Safety Education (New York: The Macmillan Company, 1966), p. 75.

> In view of the fact that approximately 90 per cent of human discriminations are based on what is seen, it is especially significant that these incoming data be interpreted properly by our perceptual processes.[9]

Perception, by definition, relates to both seeing and understanding. It is necessary, therefore, for one to identify a multitude of stimuli in the driving view and then proceed to interpret such stimuli. The most important elements of the driving task are those processes related to perception.[10]

Driver perception is an all inclusive term, and the process, because of its complexity, is difficult to determine and measure. However, one facet of driver perception that can be measured is the perception of driving hazards.

Purpose

The primary purpose of this thesis was to develop an instrument to measure a phase of that process called dynamic driver perception, primarily that of driving hazard recognition. It is believed the instrument could also be of value in improving the perceptual process of driving hazard recognition of drivers. A secondary purpose was to determine how drivers respond to the instrument.

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[9]Ibid., p. 74.

[10]Ibid.

Statement of Problem

It might be said that driver hazard perception is important to defensive driving. Drivers should have the ability to recognize situations that are not seemingly dangerous, but indeed do have potential danger. The quickness with which drivers recognize a situation that can develop into a very severe hazard if action is not taken promptly is also important. The novice driver does not recognize some situations where potential danger exists in time to take corrective action. In fact, he may not be aware of them at all. For instance, a potentially dangerous situation may not result in a problem. In others it can result in fatalities (e.g., a child playing near the road may dart out).

The objectives of this study were to (1) develop a motion picture film sequence instrument to be used as a test in evaluating the ability of drivers to recognize driving hazards, and (2) to evaluate the manner in which drivers respond to the instrument.

Subordinate Problems

Related to the above objectives the following specific questions were examined: (1) Will the instrument discriminate among drivers? (2) How promptly will the drivers recognize a hazardous situation? Or will they recognize it at all?

The Instrument

An instrument was developed consisting of fifteen, 16mm film clips or sequences depicting various types of driving hazards. The instrument includes film clips which have driving hazards that are felt to be obvious, others which have driving hazards that some drivers may recognize and others will not, and finally those which show no driving hazards. All the sequences were selected from driver education simulator training films produced by Allstate Insurance Company. These film sequences, individually numbered, were connected in a continuous widescreen film of approximately 300 feet.

The film was shown to individuals after traffic safety experts, as indicated below, had viewed, evaluated, and validated both the hazard content of each clip as well as confirming the grading system.

The Traffic Safety Experts

The traffic safety experts were people representing a variety of disciplines in traffic safety: a police officer from the Michigan Department of State Police; a specialist in motor vehicle administration from the Highway Traffic Safety Center, Michigan State University; a representative from the Bureau of Driver and Vehicle Services, Michigan Department of State; a full-time driver education teacher from the Lansing Public Schools; and a

driver education consultant from the Michigan Department of Education.

Nature of Variables

The variables are of two types: (1) the recognition vs. non-recognition of hazards in the film clip, (2) at what point in time the subject perceived the hazard.

Sample

The sample consisted of fifty-eight drivers, twenty-nine of whom were license renewal applicants, often referred to as the R or renewal group, who had no accidents or violations on their records. The other twenty-nine, often referred to as the I or improvement group, were drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent (chargeable) accidents within the past two years.

Basic Assumptions

This thesis was based on the following assumptions: Drivers being tested can respond to driving hazards they see in the driving simulation film by pressing a stop button on a hand held control. Driver perceptual capability as related to driving hazard recognition can effectively be measured using the simulated dynamic driving hazard perception test developed in this study.

Limitations

The findings and the conclusions of this study are limited to the population tested. Because of a lack of experience in viewing simulation films, some subjects being tested may not have recognized hazards in the driving environment to the rear as depicted in mirrors shown on the screen.

The Hypotheses

The hypotheses to be tested in this study were:

H_1: When measured by recognition of the driving hazards as validated by traffic safety experts, there will be a significant difference at the .05 level between the renewal and improvement groups.

H_2: When measured by recognition of the driving hazards within the limit set and validated by the traffic safety experts, there will be a significant difference at the .05 level between the renewal and improvement groups.

Definition of Terms

Driving Hazards

Driving hazards are driving situations that are dangerous or potentially dangerous as judged by the panel of traffic safety experts employed in this study.

Driver Hazard Perception

Driver hazard perception is that process that a driver is involved in when making decisions based upon the

identification of stimuli in the driving view and the interpretation of that stimuli to recognize or identify and respond to driving hazards.

Search

"An observable behavior in which the driver looks systematically toward possible sources of traffic information."[11]

Allstate Good Driver Simulator Films

Allstate Good Driver Simulator Films are 16mm color, wide-screen motion pictures depicting a variety of driving situations as seen from the driver's seat. These films were written, directed, and produced by Allstate Training Division to be used with the training unit produced by Link Division of General Precision, Inc.

Simulated Dynamic Driving Hazard Perception Test

The simulated dynamic driving hazard perception test consists of fifteen film clips or sequences each numbered and connected in a continuous 300-foot, 16mm silent wide-screen motion picture. Two of the fifteen sequences are controls with no hazards and the first one

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[11]T.W. Forbes and others, "Driver Performance Measurement Research." A Technical Report, Michigan State University, Vol. I, February 1973, p. xiv.

was used as a sample, thus leaving twelve sequences to be scored. This simulated dynamic driving hazard perception test, described more fully in Chapter III, was developed as a specific part of this thesis. It was given to the sample populations.

From this point on the simulated dynamic driving hazard perception test is referred to as SDDHPT.

Film Clips or Sequences

Film clips or sequences refer to a silent wide-screen motion picture of short duration lasting from ten to thirty seconds selected from the Allstate Good Driver Simulator Films. From this point on the term film clip or sequence will be used interchangeably. Fifteen of these clips were used to make up the SDDHPT.

Experts' Limit

The experts' limit is the location in each film sequence referred to by frame number, at or before which the subject should have stopped the projector and correctly recognized the hazard. Because of mechanical limitations the experts' limit takes into account a possible variation of five frames in the projector's stopping point.

Experts' Frame Number

The experts' frame number is a term used hereafter interchangeably with the experts' limit as defined above.

Recognition Score

The recognition score for the SDDHPT represents the total number of sequences for which the subject recognized the proper hazard and stopped the projector.

Time Limit Score

The time limit score for the SDDHPT is a subset of the recognition score for which the subject stopped the projector within the experts' limit.

R Group

The R Group consists of that portion of the sample who were license renewal applicants having no accidents or violations on their driving record.

I Group

The I Group was that portion of the sample who were required to appear at the Driver Improvement Bureau for re-examination because of three negligent (chargeable) accidents within the past two years.

Organization of Study

The general overview of this study is to present in Chapter II a review of the literature of visual perception with primary emphasis on visual perception in driving as related to dynamic driver perception tests.

Chapter III contains a description of the inception and development of the SDDHPT from the Allstate Good Driver

Simulator Films, an account of how the test was used, those who were tested, and a description of the statistical techniques applied to the test results. The results of the analysis appear in Chapter IV along with the subject's comments and a look at the relationships within the individual sequences.

Chapter V contains the summary, major findings, conclusions, recommendations for further study, and a discussion.

CHAPTER II

LITERATURE REVIEW

The literature related to driving hazard perception tests is limited; however, literature concerning perception is profuse. A computer search of perception in psychological abstracts reveals sixteen thousand entries. A few early investigations in the field of visual perception have been cited, which in some way relate to the development of the Second World War military pilot selection as well as aircraft identification programs. The selected literature review will then proceed to works of more recent researchers in perception as related to performance in varied situations including sight, athletics, driver performance, and driver perception. Finally, some driving hazard perception tests will be included.

The ability of people to recognize or perceive and then reproduce digital patterns or multiple digit numbers has been of interest to researchers for a number of years. According to Samuel Renshaw in the article "The Visual Perception and Reproduction of Forms by Tachistoscopic Methods" published in the Journal of Psychology, 1945,

Kroh made the first recorded studies of the exposure times necessary for students without special training or talent to perceive and reproduce digit patterns of differing lengths.

A precision tachistoscope was designed and built at Ohio State University in the early thirties which could produce exposures as short as .5 milliseconds with as little as two percent error. With this instrument experiments were performed in which people were trained to read large digit numbers with shorter and shorter exposure.[1]

Renshaw concluded that recognition training was best obtained with high speed presentations and that perceptual learning of wholes is better than verbal learning of parts.[2]

Because of the great need for rapidly training large numbers of pilots, the army air force early in the Second World War (June 1941) established a Psychological Research Agency ("The first psychological tests were given to aviation cadets in October, 1941, at Maxwell Field Alabama").[3]

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[1]Samuel Renshaw, "The Visual Perception and Reproduction of Forms by Tachistoscopic Methods," The Journal of Psychology, 1945, pp. 217-232.

[2]Ibid.

[3]Staff of the Psychological Branch, Office of the Air Surgeon Headquarters Army Air Forces. "The Aviation Psychology Program of the Army Air Forces, Psychological Bulletin, 40 (1943), p. 760.

A battery of tests evolved for the purpose of determining a person's aptitude and ability as a pilot, bombardier, or navigator. By October 1943, the battery of tests were grouped into four general categories:

1. Tests of intelligence, judgment, and proficiency.
2. Tests of alertness, observation, and speed of perception.
3. Tests of personality, temperament, and interests.
4. Tests of visual-motor coordination.

From the four categories of tests three scores were determined, a pilot aptitude score, a bombardier aptitude score, and a navigator aptitude score. Up to this point no test involved motion pictures.[4]

From Renshaw's experiments many variations evolved in teaching aircraft identification to military pilots in training. Some schools used short exposures such as 1/50 of a second while others used exposures up to one second.[5] Because of these variations Lester Luborsky performed an experiment in which

> Four equated groups, of 8 per-aviation (V-5) students each, were taught aircraft recognition in a standardized manner. The major experimental

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[4]Ibid., p. 764.

[5]Lester Luborsky, "Aircraft Recognition: I. The Relative Efficiency of Teaching Procedures," _Journal of Applied Psychology,_ Vol. 29, No. 5 (October 1945), p. 386.

variable in each group was as follows: Group I, 1/50" exposure time; Group II, only three views of each plane; Group III, 1" exposure time; and Group IV, presentation of the entire syllabus in almost half the usual time, followed by a review emphasizing confused planes.

The following conclusions were obtained.

1. The use of 1/50" exposures as part of training in which an approximately equal number of longer exposures are given has no ascertainable advantages over 1" exposures similarly given with longer exposures.
2. Restriction of teaching materials to only three views of each plane results in learning which generalizes poorly to views of planes other than those taught and is, in this sense, inefficient.
3. Rapid teaching followed by review of confused planes is probably the most efficient of the procedures tested.[6]

During the Second World War it was deemed important to use motion picture tests which were considered more closely resembling the real world.

> The effort was made to get away from the purely academic type of examination which puts a premium on verbal memory and to test the performance of the student in a situation having the sequence, the tempo, and the continuous change of the real situation with which he will have to deal.[7]

The advantages of motion picture tests especially for group testing, as pointed out by J. J. Gibson and summarized by Benjamin Fruchter and William W. Mahan, are: (1) movement, where both objects can move as well as the camera, (2) temporal sequence, where the projector serves as an exposure device in presenting material to a group

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[6]Ibid., p. 397.

[7]J. J. Gibson (ed.), Motion Picture Testing and Research Report, No. 7, U.S. Army Air Force (Washington, D.C.: Government Printing Office, 1947), p. 100.

simultaneously, (3) pacing, in other words, items can be presented for just the length of time desired and the exposure can be lengthened or shortened as desired by the test maker, and (4) realism, compared to verbal descriptions or still pictures, motion pictures make things more real. "These advantages are especially important for tests of perception since much greater control of the perceptual process is possible."[8]

Gibson further emphasizes the use of motion picture tests by stating

> Human behavior, and the capacities latent in it, also involves motion, order, tempo, and the experience of reality. It is reasonable to suppose, therefore, that the motion picture makes available to the test designer not only a special method of measuring known factors of human ability but also gives him access to new and unnamed functions not accessible to conventional methods of test construction. . . . The functions are as follows: discrimination of visual motion and locomotion; perception of space and distance, particularly during flight; maintaining orientation during locomotion; ability to learn a procedure; ability to react to a changing situation; ability to perform during emotional stress.[9]

Early in the war the army had set up a Perceptual Research Unit to construct aptitude tests for new aircrew candidates. In addition, research in the general field of perception was conducted. Part of this research included motion pictures. In order to improve and intensify this

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[8]Benjamin Fruchter and William W. Mahan, "Some Perceptual Factors Measured by Motion Picture Tests," Journal of Educational Psychology, XXXXIII (1952), pp. 430-435.

[9]Gibson, op. cit., p. 20.

motion picture development of perceptual testing a Psychological Test Film Unit was activated with its primary function of developing motion picture perceptual tests. A number of motion picture tests were developed.

One of the important hypotheses employed for selecting the motion picture medium for test construction was that

> It was assumed at the beginning that tests requiring discriminations of time and events-in-sequence were necessary to supplement the motionless type of visual discriminations required by paper and pencil tests already in use. Plans were made, therefore, for the development of film tests which make possible a wide range of judgments involving motion, and hence are closer to the realities of aircrew performance.[10]

Instead of describing all the perceptual tests constructed a description of one representative motion picture follows:

> One of the first test films planned was Speed Estimation Test III, Estimation of Relative Velocities, one of three tests requiring complex judgments of speed and motion. The intention was to construct a motion picture test requiring a complex judgment of the relations between two velocities, measured by estimating the imagined point at which the faster of two moving spots (planes) would overtake the slower. The paths of the two motions were parallel so that the judgment could not be reduced to a merely geometrical one.
>
> Two animated planes are seen on the screen against a skyline background, one overtaking the other. Before the overtaking point is reached, both planes disappear behind a cloud and a five point scale appears superimposed on the cloud. The testee must project the two velocities and judge at which of the five

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[10] Staff, Psychological Test Film Unit, "History, Organization, and Research Activities, Psychological Test Film Unit, Army Air Forces," Psychological Bulletin, XXXXI (1944), p. 459.

> points the two planes would coincide. The test consists of 50 trials, ten at each of the five points, in a random order.[11]

During this era a total of eleven tests using the motion picture medium were developed:

> Three, including the one described, are tests requiring estimation of visual velocities of various types. One requires reproduction, on a standard answer sheet, of briefly exposed visual patterns and is intended as a test for speed of perception. Two, entitled "Flexibility of Attention" and "Integration of Attention" respectively, are efforts to measure the ability to take account of different events occurring in the perceptual field at the same time without becoming confused. Two more tests have to do with the complex ability to form unitary perceptual experiences from a series of successive partial impressions. Two require discriminations of, respectively, just noticeable movement and just noticeable direction of movement (drift), in the field of a bombsight schematically presented on the screen. One is a test of perceptual judgment of a sort which is required in aircraft landings, consisting of shots of a runway photographed at varying moments during an approach glide, with the requirement that the trainee estimate at which of five lettered points the present angle of glide intersects the runway.[12]

A considerable number of tests measuring a variety of perceptual functions were given to aviation trainees. It was found that a wide spread of individual differences occurred as to perceptual abilities of individuals existed even in the homogenous population available.[13]

The literature is limited concerning motion pictures in testing perceptual abilities of pilots or drivers.

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[11]Ibid., p. 463.

[12]Ibid., pp. 463-464.

[13]Ibid., p. 465.

One such test was developed and conducted by Robert Spicer in Honolulu, Hawaii, as a part of a study of the human factors approach in traffic accidents. In his research Spicer investigated the human factors of attitude, frustration response, problem solving, and visual perception. In the process of investigating visual perception he developed "an eleven-scene 16mm silent motion picture film depicting typical city and highway traffic conditions."[14] Visual perception was the only one of the variables tested which seemed to show some consistent relationship to driving and traffic mishaps. Evidently there are visual cues related to vehicle operation that are peculiar to driving and different from general visual alertness.

Further emphasis is placed on driver perceptual skill by the following statement:

> The factor of perception has been advanced as an inherent element of the driving situation, and the degree of visual alertness or perceptual skill an individual possesses should affect to a considerable extent, his success in operating a vehicle without mishap. To an even greater extent, his ability to utilize the information provided by his perceptivity (effective problem-solving following perception of stimuli) should be a determinant of accident status. Conversely, a motorist may still find himself repeatedly involved in accidents, despite his efficiency at problem-solving, if he has never learned to look for critical cues on the highway.[15]

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[14]Robert A. Spicer, "Human Factors in Traffic Accidents," Research Grant AC-55, U.S. Public Health Service, Department of Health, Education and Welfare (Washington, D.C.: U.S. Government Printing Office, 1963), p. 14.

[15]Ibid., p. 11.

Eugene D. Carney describes the many facets of perception from the standpoint of the driver education teacher. One of his important ideas is that

> Greater perceptual efficiency is achieved when the driver realizes that the highway circumstances or developments that require significant physical response result very frequently from a change in the traffic scene. For example, stationary vehicles suddenly begin to move, moving vehicles suddenly stop or change direction, pedestrians and animals suddenly stop, start or change direction, or vehicles, pedestrians or animals suddenly appear on the highway from an area where the driver's vision was restricted. Consequently, it is important for the driver to realize that he must continually recycle his perceptual stimuli so that he is immediately aware of any need to respond.
>
> Visual identification activates the perceptual skills in all but a few instances.[16]

Admitting that the task of driving a car is not a simple one in modern traffic, T. W. Forbes as far back as 1959 made the following observations concerning perceptions, judgments, and responses:

> In analyzing the driver's task, we find that perception of rapidly changing situations, judgments based on these perceptions plus background knowledge, and responses adequate for each situation are the essentials. The judgments made by the driver are based upon information about the highway situation and about possible hazards which may be so well learned that it is automatically rather than consciously used. Such information is nonetheless very vital.
>
> I should like to suggest here that two kinds of specific, factual information affect very importantly (1) the difficulty of the driver's task and (2) the accuracy and effectiveness with which he responds in driving modern highways. These two kinds of information are: (1) what the driver does and doesn't know about the best procedures for operating the vehicle on modern highways and (2) what the highway designer

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[16]Eugene D. Carney, "Another Look at Perception," Journal of Traffic Safety Education, XIX, 2 (1972), p. 32.

> and traffic engineer knows (and applies) about human limitations and operator abilities. Even though technical engineering personnel may not be able to delve into human factor research, specialists in this area can obtain and supply information to them if given an opportunity.[17]

Ross A. McFarland indicates in "Human Factors in Highway Transport Safety" that a number of tests and studies have been conducted concerning the selection of bus and truck drivers.

Parameters for a successful psychological testing program were outlined as follows:

> (1) determine adequate criteria of the job requirements in successful driving, (2) devise specific tests for professional drivers and do not simply use measures which have been developed for other purposes, (3) carry out adequate follow-up studies through a period of years so that new items can be added and poor ones discarded, and (4) select a large group of drivers to study. (5) The group should be relatively stable, homogeneous in experience background, and uniform in exposure to risks. Also each driver should have a reasonably prolonged period of exposure to his job so that individual differences will be revealed.[18]

The results of a study to evaluate the psychological characteristics of successful truck drivers revealed (1) generally that

> drivers tended to show normal variability in the following traits and interests: (a) appreciative, (b) quiet, (c) submissive, (d) cold, (e) scientific, (f) persuasive, (g) literary.
>
> (2) Group characteristics indicated by the test items were: (a) higher mental ability than average,

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[17] T. W. Forbes, "Human Factors in Highway Safety," Traffic Safety, IV (March 1960), p. 8.

[18] Ross A. McFarland and Alfred L. Moseley, "Human Factors in Highway Transport Safety," (Boston, Massachusetts: Harvard School of Public Health, 1954), p. 30.

(b) composure, (c) optimism, (d) sympathetic tendency, (e) objectivity, (f) impulsiveness, (g) appreciativeness, (h) quietness, (i) submissiveness, (j) coldness, (k) somewhat high interests (though in average range) in respect to 1) mechanical, 2) artistic, 3) musical, 4) social service, 5) clerical areas; 1) low interests in ten computational, 2) scientific, 3) persuasive and 4) literary areas.

(3) The scores describe a 'person' who can work alone within a limited working space, who can be quick to respond in emergency situations, and whose interests are so lacking in extremes as to foster acceptance of the limiting aspects of the occupation.[19]

A car operator's mood can obviously affect his perception and ability to control a car. Norman W. Heimstra, Vernon S. Ellingstad, and Arlan R. DeKock performed an experiment in which subjects were first given a mood check list and then tested in a simulated driving task. It was found that "Ss scoring high on factors of aggression, anxiety, and fatigue performed more poorly on various tasks than Ss who scored lower on these factors."[20]

In a synopsis paper presented at the S.A.E. Golden Anniversary Transportation Meeting in St. Louis, Missouri, on November 2, 1955, McFarland in discussing analysis of driver activities and critical incidents states on page 733:

When the task of driving itself is employed as the logical, starting point, a rational analysis indicates that anticipation, foresight, and continued alertness on the part of each driver are required to

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[19] Ibid., p. 37.

[20] Norman W. Heimstra and others, "Effects of Operator Mood on Performance in a Simulated Driving Task," Perceptual and Motor Skills, XXV (December 1967), p. 729.

> avoid accidents. Thus, any feature which may distract attention, interfere with perception, lengthen reaction times, or hinder the completion of required responses may directly compromise safety. Other features, in themselves less critical, may however result in reduced efficiency if they force the driver to operate near, or beyond, the limits of his normal capacities. Such features may also accumulate in their effects, adding to fatigue.

In a paper written by Lawrence E. Schlesinger and Miriam A. Safren which was read to the Annual Meeting of Highway Research Board in January 1964, the authors attempted to develop a unified comprehensive model of the driving task. According to the authors

> In the model, the major tasks for the driver are the perceptual organization from moment to moment of a field of safe travel (a region in which the car can move unimpeded), a minimum stopping zone (the smallest region through which the car must move to come to a full stop), and a comparison of these two fields. The driver's organization of these two fields, or the field-zone ratio is a control stimulus guiding the control actions to the vehicle. That is, the driver varies the speed and direction of movement of the vehicle to maintain a safe field-zone ratio; that is, one in which the field is greater than the zone.[21]

Visual perception is then the underlying principle in safe driving of which driving hazard perception is a part.

H. Laurence Ross studied forty-three ordinary traffic accidents intensively. He concluded that the most common circumstance was that the driver was not aware that he

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[21]Lawrence E. Schlesinger and Miriam A. Safren, "Perceptual Analysis of the Driving Task" (paper read at the Annual Meeting of Highway Research Board, January 1964), p. 11.

was on a collision course. Two reasons for his unawareness were delayed perception and erroneous prediction.

> Delayed perception occurred because of impediments to vision and inattentiveness. In only one accident was the impediment to vision due to eye defects; in seven it related to vehicle conditions such as obscured windshields and passenger interference; in 21 cases it arose from view obstructions outside the vehicle, the most common being roadside structures and the next most common, parked cars. Inattentiveness contributed to delayed perception in almost the same number of cases as impediments to vision. It contributed in the form of inadequate scanning habits, preoccupation, distraction within the vehicle, distraction outside vehicle, and inattentiveness to rear, the latter being the most common.
>
> Erroneous predictions resulted when drivers expected other vehicles to continue moving as they had been, failed to receive a signal from the other driver of his intent to turn or slow, depended on others to observe signs and signals, or did not expect the unexpected from other drivers in numerous traffic situations. The reasons for failure of expectations seemed to be insufficient cues as to behavior of the other driver, action on his part that may suggest any of several actions, and actions of his that differ from that prescribed by law or based on custom.[22]

Nick Rackoff investigated the effects of aging on driver performance. He found among other things that perceptual skill goes down with age. However, he states:

> What this study does demonstrate is the large variation in performance capabilities from one aged subject to the next. Some subjects could hardly be distinguished from young while others showed large deviations. . . . Chronological age alone is a very poor indicator of an individual's capability to drive.[23]

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[22] H. Laurence Ross, "Ignorance of Collision Course as a Factor in Traffic Accidents." Traffic Institute, Northwestern University, Evanston, Illinois, 1960, pp. 23-24.

[23] Nick Joseph Rackoff, "An Investigation of Age-Related Changes in Driver's Visual Search Patterns and

Raymond Reilly and his associates attempted to determine the manner in which certain items of perceptual information are used by the driver in beginning and guiding the braking response in the process of bringing the vehicle to a safe stop behind a lead vehicle under night conditions.

> Measures of the distance from the display at which deceleration began and the magnitude of the braking response were then examined to discover whether these responses were systematically related to variations in the visual cues under study.[24]

The three visual clues studied were taillight area, brightness, and angular velocity.

It was concluded that a driver uses angle velocity and vehicle velocity information to make the decision to stop. Also, a vehicle with bright wide-spread taillights produce the best braking response.

The complexity of the perceptual processes is emphasized by the following comments:

> . . . There are, to be sure, many aspects of driving behavior which appear to be considerably more complex than initially envisioned and which do not conform to earlier predictions. In all instances, however, a very definite regularity is noted in the data. The decision to decelerate and to exert a certain magnitude of braking force seems to be a carefully ordered response by the driver to the visual world

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Driving Performance and The Relation of Tests of Basic Functional Capacities" (Doctor's dissertation, Ohio State University, 1974), p. 204.

[24]Raymond E. Reilly and others, "The Translation of Visual Information into Vehicular Control Actions," Report Biotechnology, Incorporated, Arlington, Virginia, October 1965, p. 5.

> around him and to his expectations as to how this world should behave.
>
> In general, these results mediate against the treatment of human responses in mechanistic terms. Simple functional relationships do not exist between human behavior in a given situation and isolated perceptual variables which might be present. The human operates within a 'framework.' In the present instance, this framework is influenced by such aspects as his insight into the purposes of the experiment, his knowledge of the speed of his vehicle, and his awareness of the consequences of a mistake while traveling at a given speed.[25]

Richard Lucas investigated a method to improve the accuracy of drivers' last moment passing judgments. A motion picture test was developed in which subjects would indicate the last possible time in the film that they could pass a car. One group of subjects were given the motion picture training with feedback as to their accuracy while the other group was given no feedback. Both groups took a behind-the-wheel pre and post car passing test. The results indicated the feedback group improved while the no feedback group showed no improvement. The feedback group did "improve in the ability to make last minute passing judgments"[26] while the no feedback group did not improve. Neither group performed superiorly on the final test. This is another attempt at trying to check the perception ability of drivers on a specific task.

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[25]Ibid., p. 38.

[26]Richard Lawrence Lucas, "Development and Evaluation of a Part Task Film Simulation Technique for Training Drivers on Critical Passing Skill" (Doctor's dissertation, University of South Dakota, 1970), p. 73.

Albert Burg studied driver visual acuity both static and dynamic and compared the findings with driving records. His conclusions were that a relationship between static visual acuity and the driving record could not be supported. The study seemed to indicate a positive relationship between dynamic visual acuity and driving record; however final confirmation or rejection must await a repeat using a greater sample. He states that "DVA (dynamic visual acuity) performance is potentially a more valid predictor of driving performance than is static acuity score."[27]

No studies were found which indicated that hazard recognition would be more valid if conducted under dynamic conditions.

From Burg's work it would seem that the use of the SDDHPT, which is a dynamic test, would be a reasonable approach. Only further research will give more definitive data.

R. L. Newsome conducted a study of peripheral vision in which two experiments were performed. In the first experiment square blocks were placed in the peripheral vision of subjects so as to look the same size as

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[27]Albert Burg, "An Investigation of Some Relationships Between Dynamic Visual Acuity, Static Visual Acuity and Driving Record" (Doctor's disseration, University of California, Los Angeles, 1964), p. 95.

a block straight ahead. The greater the angle of peripheral vision the closer the block had to be moved to the subject.

In the second experiment the subject stood facing a man at a definite distance on a playing field. The subject was asked to stop a walking man in the subject's peripheral view when both men appeared to be the same size.

From the above experiments it was concluded that objects from a side road may appear to be much further away than the real distance. The perception of peripheral objects may or may not be a hazard to drivers.[28]

An interesting conclusion from a peripheral visual field study by A. T. Slater-Hammel was that "an athlete's reaction time to stimuli directly perceived will apparently provide an excellent relative index of his reaction speed to stimuli along the peripheral visual field."[29]

Albert Burg in 1964 made an extensive study of the literature regarding the role that vision plays in driving and found that there was a discouraging lack of any conclusive findings. This work cited in 1967 indicates that the situation had not changed appreciably. He states:

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[28] L. R. Newsome, "A Perceptual Factor That Could Contribute to Road Accidents," Road Research Laboratory Ministry of Transport, RRL Report LR 135, 1967.

[29] A. T. Slater-Hammel, "Reaction Time to Light Stimuli in the Peripheral Visual Field," Research Quarterly, XXVI (March 1955), pp. 82-87.

> To summarize our current state of knowledge, it is obvious that at the present time there is no widely recognized evidence that vision is related to driving. Everyone will readily admit that there must be a relationship, but as yet there is no way of translating this 'feeling' into valid and useful practice, such as the development of practical vision-test standards for driver-screening agencies.[30]

Burg gives some interesting factors that he thinks may be reasons why attempts to relate vision and driving have been inconclusive.

> 1. Accidents are rare and complex events, usually involving a number of factors. Vision is only one of these factors, and while it is undoubtedly important, vision's contribution may be small enough to make it difficult to show a significant relationship.
>
> 2. 'Driving Ability,' 'Driving Performance,' and 'Driving Record' are three separate concepts. 'Ability' is the one we would like to be able to measure, but cannot with any degree of confidence. 'Performance' is an approximation of 'Ability,' but cost, time, and legal factors make it impossible to obtain any truly representative sample of driving performance for the large sample of drivers essential to research of this type. This leaves us with 'Driving Record' which we can ascertain, but without any assurance that we have obtained an accurate or complete estimate of the driver's on-the-road performance, over the specified period of time, because of the lack of consistency and completeness in reporting accidents and traffic citations.
>
> Vision is very likely an important factor in both driving ability and driving performance. Driving record, however, is influenced strongly by the element of chance or luck and thus is, at best, an uncertain indicator of true driving ability. It seems that we are in a 'heads you win, tails I lose' sort of situation since we do not, as yet, have the means to measure true driving ability, and thus are forced to use driving record (which is two steps removed from driving ability) as the criterion. At present we have no alternative.

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[30]Albert Burg, "Some Preliminary Findings Concerning the Relation Between Vision and Driving Performance," Journal of the American Optometric Association, XXXVIII, 5 (May 1967), p. 372.

3. The vision tests used may not be valid. That is, they may not be related to the visual functions used in driving. These functions, needless to say, have yet to be established in any conclusive fashion.

4. The reliability of the vision test and/or of the measure of driving ability used (e.g., driving record) may be low. It is well known, for example, that the correlation between driving records in adjacent periods of time is low.

5. What the person is capable of seeing and the use he makes of this capability in driving may differ substantially. In other words, there may be considerable disparity between an individual's physiological vision and his functional vision. (A complicating factor, here, is that the individual may, to a certain extent, be able to compensate for his visual shortcomings, thus making unsafe vision in driving).

6. Using drivers as our subjects, as we must, we necessarily are dealing with a restricted range of visual capabilities.[31]

At the time Burg stated that there was no means of measuring true driving ability, the Michigan State University Driver Performance Measurement Research project had not yet been undertaken. However, that research has been completed and the first two paragraphs of the preface best describe what this research intended to accomplish in terms of a valid and reliable measure of driving performance.

> This is a two volume final report of research carried on over a period of more than two years, to develop a reliable and valid method of measuring safe and good driving applicable for small group research to improve driver education methods. Problems caused by the many unknown and variable factors in accident records had been shown by state of the art studies, from which the need for an immediate, usable method of measuring safe and good driving had become clear.
>
> None of the previous research, however, had shown how much a reliable measurement of safe and good

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[31] Ibid., pp. 372-373.

> driver behavior could be accomplished. In this project, therefore, the research team had to first consider fundamentals; then develop the method, refine it, try it out, evaluate it, train others to use it, and then evaluate their results.[32]

Other disciplines have developed visual perception tests of various sorts. James Wise developed and pretested a visual perception test using slides of different shapes and colors projected on a screen by a tachistoscope.

Intentions of the test were to serve as a screening device in determining preschool children's visual perceptual capabilities. It did differentiate between subjects who were performing at teacher expectations and subjects who were not.[33]

Harriet Williams measured perceptual ability of athletes by projecting a tennis ball with a tennis ballboy machine. Subjects were to visually judge the flight path, then immediately move to a point of interception. A canvas, suspended four to five feet above the head of the subjects, prevented actual physical contact with the ball. Movement time, reaction time, and measures of spatial accuracy were recorded.

Three main purposes of the study were:

> (i) to assess the effects of systematic variation in velocity and direction of ball flight upon visuo-

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[32]Forbes and others, p. i.

[33]James Elton Wise, "Development and Pretest of a Visual Perceptual Screening Test for Use in Preschool Education" (Doctor's dissertation, University of South Carolina, 1973).

perceptual judgments made about moving objects in space; (ii) to determine whether or not highly-skilled and poorly-skilled performers differ in their ability to visually judge the flight of a moving object in three-dimensional space, and (iii) to assess the effect of age or maturity level of the individual upon the speed and accuracy of such visuo-perceptual judgments.[34]

The results are summarized as follows:

(1) The speed and accuracy with which the flight of a moving object was judged was, to a large extent, dependent upon the specific set of visual cues involved, that is, upon the particular speed, horizontal and/or vertical direction in which the object was moving at the time it was being judged. This of course suggests that if we are to enhance the degree of success experienced by the individual in learning and/or performing certain gross motor skills, we need to begin to identify more specifically the kinds of visual cues involved in the performance of motor skills and to evaluate them in terms of the kinds of demands which they place upon the sensori-perceptual apparatus of the individual.

(2) Individuals classified as highly-skilled were significantly superior to individuals classified as poorly-skilled in visually judging the flight of a moving object in space. Such findings tend to support the notion that the highly-skilled performer may, in fact, possess a sensori-perceptual mechanism that is superior to that of the unskilled performer. If such differences in the visuo-perceptual capacities of the highly-skilled and the poorly-skilled sports performer do exist, it is important that we begin to establish whether or not such differences are innate ones or if the 'potentially' unskilled individual can be trained to use his visuo-perceptual apparatus more effectively through properly planned and appropriately timed perceptual-motor experiences.

(3) Age, as represented by a sample of junior high, high school and college age males, had little or no effect upon the speed and accuracy with which the individual judged the flight of a moving object in three-dimensional space.[35]

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[34]Harriet G. Williams, "The Effects of Systematic Variation of Speed and Direction of Object Flight and of Skill and Age Classifications upon Visuo-perceptual Judgments of Moving Objects in Three-dimensional Space" (Toledo University, Ohio), report no. BR-6-8102, January 1968, p. I.

[35]Ibid., p. II.

Football players were trained by C. Frazier Damron in defensive formations using two and three dimensional slides exposed tachistoscopically. The group trained with two dimension slides performed higher in correct responses than the three dimension trained group. He concluded that the entire training method had great potential for teaching football defense recognition in a short time period and in a classroom environment.[36]

Ben R. Londeree divided football players into two groups and trained them for play recognition from the defensive end position. One group was trained using motion pictures while the other group was trained with flash cards. When tested in a live situation for the quickness of recognition, the motion picture-trained group recognized the football plays in significantly less time than the flash card-trained group. Here again the process involved perception of different plays where motion of the players obviously was of great value in early recognition.[37]

Charles Thiffault, in a study designed to evaluate how tachistoscopic training effects the perceptual ability of ice hockey players, discovered the results to support

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[36]C. Frazier Damron, "Two- and Three-Dimensional Slide Images Used With Tachistoscopic Training Techniques in Instructing High School Football Players in Defenses," Research Quarterly, XXVI (1955), pp. 36-43.

[37]Ben R. Londeree, Jr., "Effects of Training with Motion Pictures Versus Flash Cards Upon Football Play Recognition," Research Quarterly, XXXVIII (May 1967), pp. 202-207.

his working hypothesis that tachistoscopic training can improve visual perception in ice hockey players. The tachistoscopic training did improve the players' ability to appraise and react to tactical situations in ice hockey.[38]

A number of studies in driver hazard perception have been undertaken. Many have included 35mm slides of driving hazards rather than motion pictures. The test most commonly used by researchers at Illinois State University has been The Perception of Traffic Hazards Test (PTHT) which was developed at that institution.

Francis Kenel says,

> Safe drivers must depend upon the development of accurate judgments and correct decisions for determining their mechanical control over the vehicle. These judgments and decisions are, in turn, based primarily on the driver's perception of the traffic scene.[39]

Kenard McPherson using the PTHT endeavored to find how IQ and the perception of traffic hazards were related. Three groups were given instruction with traffic simulator films selected from Aetna and Allstate. As a result of his work he concludes:

> The findings of this study suggest that training in driving simulators using programmed films will improve an individual's ability to perceive traffic hazards.

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[38]Charles Thiffault, "Tachistoscopic Training and Its Effects Upon Visual Perceptual Speed of Ice-Hockey Players." (Doctor's dissertation, University of Southern California, 1974.)

[39]Francis C. Kenel, "Employment of Teaching Assistants in Driver Education," Safety, April 1970, p. 14.

> These findings appear to be relatively constant with each of the three classifications studied.[40]

Gerald M. Streeter conducted special classroom visual training with instruments similar to the tachistoscope for an experimental group of driver education students prior to the laboratory instruction. He used the PTHT in a test-retest method to measure perceptual growth. It was concluded that

> Visual perceptual ability as indicated by the recognition of potentially hazardous traffic events in a filmed situation presented in a classroom environment can be improved without employing sophisticated costly apparatus.[41]

Allen Robinson administered the PTHT in a test-retest method to two groups of high school driver education students. The control group received conventional simulator instruction while the experimental group received the same instruction in a classroom setting. As a result of this research he states:

> The findings of this study indicate that visual perception of traffic hazards and events can be developed to comparable levels through the use of a conventional traffic simulator laboratory or by use of the classroom simulation method when utilizing programmed instructional films and active teacher instruction.[42]

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[40]Kenard McPherson, "Perception of Traffic Hazards: A Comparative Study (Master's thesis, Illinois State University, 1966), pp. 40-41.

[41]Gerald M. Streeter, "A Classroom Visual Perception Program for Beginning Motorists," (Master's thesis, Illinois State University, 1968), p. 30.

[42]Allen Robinson, "The Influence of Programmed Instructional Films on Perception of Traffic Hazards" (Master's thesis, Illinois State University, 1968), p. 44.

Ralph O. Johnson trained culturally and economically deprived driver education students using visual perceptual training. This consisted of 35mm slides of digits and traffic signs as well as actual traffic events flashed on the screen for short periods of time to develop fast recognition. The PTHT was administered as a pretest-posttest to measure perceptual ability. According to Johnson,

> This visual perception program using a 'static' training medium proved positive and appropriate for disadvantaged youth; therefore this instructional method may be employed to enhance the visual perceptual capabilities of the deprived student.[43]

Ronald L. Thomas divided a driver education class in half giving a traditional course to the entire group. However, with one half the class special training sessions were conducted using 35mm slides containing digits, traffic signs and traffic situations. The class was measured before and after treatment with the PTHT as well as the Streeter Numbers and Signs Test. Thomas concluded that

> The results of The Perception of Traffic Hazards Test indicate that visual stimuli recognition level of a student can be significantly raised with a classroom visual training program of this type.
>
> The inferences derived from the test results obtained from the Streeter Numbers and Signs Test indicate that these students did not significantly improve

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[43]Ralph O. Johnson, "A 'Static' Visual Perceptual Training Program for Minority Ethnic Groups" (Master's thesis, Illinois State University, 1970), p. 31.

in their ability to identify numbers and signs as presented in this test instrument.[44]

Donald Louis LaFond gave a control group of driver education students a traditional driver education course of thirty hours class instruction and six hours behind-the-wheel instruction. The experimental group received the same training with the addition of dynamic visual training films integrated into the classroom phase. LaFond's conclusions were thus:

1. The ability of beginning drivers to identify visual stimuli as measured by The Perception of Traffic Hazards Test is increased through the use of dynamic training films.
2. Traditional classroom and laboratory experiences also appear to increase the ability to identify visual stimuli as measured by The Perception of Traffic Hazards Test but to a lesser degree.
3. There is a significant relationship between dynamic visual training of beginning drivers and the drivers' manipulative skills of steering and braking as measured by the Drivometer.
4. There is a significant positive relationship between dynamic visual training and gross eye movements as recorded by a video tape recorder.[45]

Robert S. Lazarewicz investigated the relationship between behavior characteristics and visual perception of young drivers using the Mann Inventory and the PTHT. He found no significant difference between behavioral

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[44]Ronald L. Thomas, "A Comparison of Two Types of Classroom Presentation of Visual Stimuli Recognition in Driver Education" (Master's thesis, Illinois State University, 1970), pp. 26-27.

[45]Donald Louis LaFond, "The Effect of Dynamic Visual Training on Manipulative Driving Skills" (Master's thesis, Illinois State University, 1970), pp. 50-51.

characteristics and visual perceptual ability among drivers.[46]

Dale W. Goby's study was similar to Lazarewicz's, but used rural students. He states that

> The findings of this investigation tend to indicate that no significant difference exists between visual perceptual abilities and behavioral types among beginning motorists as measured by the test instruments employed.[47]

W. Laurance Quane's study was of greater magnitude than either Lazarewicz's or Goby's including subjects from suburban, inter city and city residential areas. This greater magnitude and cross cultural approach allowed for all ethnic, social, cultural, and economic backgrounds to be included. Even so the results of the study showed no direct relationship between personality factors and visual perception capabilities as measured by the instruments used.[48]

Jerrold Glassman developed a paper-pencil test to measure knowledge of correct response in selected hazardous

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[46] Robert S. Lazarewicz, "The Relationship Between Behavioral Characteristics and Visual Perception" (Master's thesis, Illinois State University, January, 1970), p. 36.

[47] Dale W. Goby, "The Relationship Between Visual Perceptual Abilities and Behavioral Categories Among Beginning Motorists" (Master's thesis, Illinois State University, 1970), p. 39.

[48] W. Laurance Quane, "The Relationships of Visual Perceptual Capabilities as Measured by The Perception of Traffic Hazards Test and Behavioral Categories as Measured by the Mann Inventory" (Doctor's dissertation, Michigan State University, 1970).

driving situations administered to three groups of driver education students: (1) those who had been instructed in the conventional way, (2) those who received programmed instruction, and (3) those who had received seeding programmed instruction. The results indicated the control group did as well as the programmed groups, but did not retain the information as long as evaluated by a second posttest. No difference appeared in the study between the seeded and nonseeded program instruction.[49]

After giving three groups, novice, student, and experienced drivers, tachistoscopic instruction in recognition to collision-producing situations using two- and three- dimensional color slides, Keith Barenklau tested the three groups by tachistoscopic means. He found that the instruction significantly improved their recognition and responses to collision-producing situations. However, "the results of responses obtained from the use of three-dimensional slide images as opposed to those obtained from the same slides shown in two dimensions"[50] was not significantly different. Barenklau went to great length

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[49]Jerrold Glassman, "The Effectiveness of A Teaching Machine-Program as Compared With Traditional Instruction in the Learning of Correct Responses to Hazardous Driving Situations" (Doctor's dissertation, New York University, 1965).

[50]Keith Edward Barenklau, "Improving Driver Recognition of and Response to Collision Producing Situations Through Tachistoscopic Instruction" (Doctor's dissertation, The University of Wisconsin, 1972), p. 69.

producing the slides. All were developed using pictures of scale models built by him. All situations were developed in conjunction with the National Safety Council's records to exact specifications.

James R. Adams developed a different driving hazard perception test in which he researched methods to measure driver hazard perception ability by the use of photographs of traffic hazard situations. Each photograph is covered with blocks. The subject, by removing blocks, uncovers the hazard picture. Evaluation is based on the number of blocks removed, the number of hazard cues described, as well as consistency of response style. The scores were compared with voluntary driving records furnished by the subjects. Subjects tested were employees of an insurance company, teachers in training, and peace corps volunteers. It was found that smaller stimulus size scores were associated with higher accident indexes (as reported by subjects).[51]

Sanford Weinstein conducted a study that closely parallels Adams, however, a small 11-inch by 14-inch rear view projection screen was used in projecting color slides. These pictures were covered with a small portion of the picture being revealed at one time. The scores were

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[51]James R. Adams, "Measurement of Hazard Judgment by a Stimulus Accretion Technique" (unpublished Safety Research and Education Project, Teachers College, Columbia University, February 1968).

determined in a manner similar to Adams. Volunteers from a real estate company served as subjects. Two hypotheses were tested. The first hypothesis was intended to measure the subject's capacity or ability to recognize the hazards presented in the slides and said that it would be inversely related to an accident involvement score. This was not confirmed; therefore, there was no statistical confirmation between hazard recognition and accident involvement.

The second hypothesis indicated that those subjects who were more cautious about making decisions when looking at the hazard pictures also had low accident involvement. This second hypothesis was confirmed. The author says the "confirmation of hypothesis 2 indicates that a lack of cautiousness is associated with accident involvement."[52] However, it seems to this writer that those who took a long time to decide on the hazards in the still picture would not do well in a dynamic situation. Therefore, one could come to just the opposite conclusions.

Weinstein states:

> A major problem in the study of driver behavior is the lack of adequate and reliable criteria for measuring driver performance. The use of inadequate criteria has led to confusion rather than knowledge in the field of traffic safety.[53]

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[52] Sanford Arthur Weinstein, "Recognition of Photographed Traffic Hazards as an Indicator of Automobile Accident Involvement" (Doctor's dissertation, Columbia University, 1970), p. 68.

[53] Ibid., p. 16.

The Michigan State University Driver Performance Measurement Research Project is a major step in developing the criteria for measuring driver performance.

Project METER conducted in the State of Washington included among other tests a motion picture of traffic events as viewed from the auto. The filmed traffic situations were used in conjunction with a simulator in an experimental driver examination program. It was decided that the simulator test could not be used to replace the road test; however, improved film tests could provide potentially useful road test supplements.[54]

At the end of an extensive literature review of motion pictures and perceptual research, Jacqueline Herkowitz states: "The use of film in perceptual testing is a relatively recent innovation. There has been little done to date, but the future looks promising."[55]

Visual perception is a major factor in the avoidance of traffic hazards. Why then has there not been more work done in the development of evaluation instruments to measure the phenomenon of traffic hazard perception?

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[54]State Department of Motor Vehicles, "Project: Machine, Examination, Teaching, Evaluation and Re-education" (evaluation prepared under contract #Fh-11-6832 with the U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1971), p. 35.

[55]Jacqueline Herkowitz, "Filmed Test to Assess Elementary School-Aged Children's Perception of Embedded Figures Which Appear to Move Away From Stationary Backgrounds" (Doctor's dissertation, Purdue University, 1971), p. 68.

This study is an attempt to start such a process by the development of a Simulated Dynamic Driving Hazard Perception Test and the administering of the instrument to a sample population.

Summary

Literature relating to driving hazard perception tests is limited, but literature dealing with perception is plentiful.

A few early investigations in the field of visual perception were cited such as the works of Samuel Renshaw and Lester Luborsky which relate to the development of the Second World War military pilot selection and aircraft identification programs.

A few works that discussed the Army's Perceptual Research Unit and Psychological Test Film Unit along with a description of a sample motion picture perceptual test were reviewed.

After a brief description of the research of Robert Spicer in visual perception, a number of articles were reviewed that dealt with human factors and perception. Several works dealing with vision as related to perception both in drivers as well as some studies in athletes were included. Albert Burg indicated that there was a surprising lack of conclusive findings regarding the role of vision in driving. He also gave some opinions as to the causes.

Next a variety of works using visual perception tests of various sorts were reviewed, concluding with driving hazard perception tests. Only a few driving hazard perception tests have been developed. One has been used by a number of researchers at Illinois State University.

Driving hazard perception tests using motion pictures have not been pursued to any extent, however, it is the belief of this author that efforts should be put forth in this direction.

CHAPTER III

DESIGN AND METHODOLOGY

The Simulated Dynamic Driving Hazard Perception Test

The Simulated Dynamic Driving Hazard Perception Test was developed as a part of this project. It is believed that no such test of this nature has been previously developed using wide-screen simulator motion pictures.

Simulated Dynamic Driving Hazard Perception Test Development

The idea first evolved in discussion with Dr. Robert Nolan of the Michigan State University Highway Traffic Safety Center as to the possibility of doing further work with the study that had been done by William Laurance Quane in the unpublished theses, "The Relationship of Visual Perceptual Capabilities as Measured by the Perception of Traffic Hazards Test and Behavioral Categories as Measured by the Mann Inventory."

It was decided that a different approach to the visual perception test might be a useful tool. A series of discussions lead to the idea of using simulation films for the purpose of developing some sort of dynamic driving hazard perception test.

At first it was felt that a group of subjects could view a short sequence of the film and then answer questions on the test. This idea was similar to the method used in the perception test developed at Illinois State University. That test used 35mm slides rather than 16mm motion pictures. They also lacked the cinemascope or wide-screen effect.

The group-showing idea was relinquished in favor of a system designed to measure an individual's ability to respond as he/she viewed the motion picture. A device was developed that allowed the person being tested to stop the projector when he/she saw a hazard or potential hazard that in his/her opinion needed some action on the part of the driver, such as acceleration, deceleration, braking, steering right, steering left, etc. Through such a system driver perception was measured.

To test the feasibility of the project an old simulator film was used from which was taken short sequences. The frames of each sequence were numbered individually in order to distinguish at what point the person being tested had stopped the projector. Using this film a small pilot study was conducted. It was evident from the success of this trial that the endeavor should be continued.

Contact was made with Mr. Ralph Jackson of Allstate Insurance Company who in a personal interview held in

Northbrook, Illinois, supported the proposed study and agreed to provide Allstate Simulation films for the project.

After reviewing the entire series, six films were selected. The titles were: Critical Situations, Hazardous Situations, Driving in Review, Control, Expressways are Different, and Complex Traffic.

Sixty-five clips or sequences were cut, spliced, and numbered. Sequences were selected because they showed a variety of hazardous driving situations including city, residential, rural, highway, and limited access highway conditions and insofar as possible were representative of the driving events included in the behavioral-environmental-traffic-situational-sequences as depicted and defined in the Michigan State University Driver Performance Measurement Research project.

> This was a process of selecting and diagraming locations typical of everyday driving and describing possible traffic sequences and driving behaviors to be expected. The term 'BETSS' (Behavioral-Environmental-Traffic-Situational-Sequences) resulted from a long series of observations and discussion. This term emphasizes the dynamic interrelationships of behaviors and changing traffic situations and helps to avoid a tendency to think in terms of physical location characteristics only.
>
> 1. A BETSS is defined therefore, as a Behavioral-Environmental-Traffic-Situational-Sequence which involves both changing traffic situations at a selected location and possibly driving behavior patterns related to these.[1]

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[1]Forbes and others, p. 57.

A process to reduce the number of sequences to a practicable number began. In the first evaluation, which was conducted with volunteer students of the instructional media class at Andrews University, driving hazard content of the sequences were rated by each individual on a basis of one to five, with five being the highest score. In the second evaluation both student and faculty volunteers from the Industrial Education Department of Andrews University rated the sequences from one to ten. Subsequently the sixty-five were reduced to twenty-three sequences. At this point a pilot study was conducted of twenty volunteers selected from the student body, faculty, and staff of Andrews University. They were tested individually, which was the procedure intended to be used with the final instrument.

Results from the pilot study included changes in the instructions given to the participants, establishment of the hazards to be named for each sequence, as well as the film frame number to be used for scoring the sequence. Also a number of sequences were deleted and two new ones added to insure that sufficient sequences were available with no apparent hazards.

The instrument was then ready for review by the experts to validate the hazards and the scoring system. They were asked to view each sequence of the instrument, note the hazard, confirm its existence in that sequence,

and approve the frame number by which the examinee should have stopped the projector in order to receive credit.

The recognition score was composed of the number of sequences for which the subject stopped the projector and correctly identified the hazard. The time limit score consisted of the subset of the above sequences for which the subject stopped the projector within the experts' limit.

Both hazards and frame numbers had already been worked out, but it was important to have the experts' confirmation as well as recommendations where adjustments were to be made. When this was completed, the sequences were renumbered and put in final form consisting of fifteen clips, individually numbered and connected in a continuous film of three hundred feet.

The first clip was used as a sample so that the subject would have a full understanding of how he was to respond to the instrument. Numbers 3 and 14 are controls with no hazards. The possible score was 12 for the recognition as well as the time limit score.

The Sample

Mr. Allen E. Bard, administrative assistant for the Bureau of Driver and Vehicle Service, Michigan Department of State, who served as one of the validation experts, suggested that his department would be interested in having the perception test used on two groups of people.

Subjects were grouped as follows: (1) Drivers who had had three negligent accidents within the past two years and were required to appear for reexamination at the Driver Improvement Bureau. (2) Drivers who were renewing their license and had had no accidents or violations on their driving records. All subjects were from Lansing, Michigan, or the immediate area and had been licensed operators for a minimum of four years.

Rural country roads to cross-town expressways and rural limited access highways as well as urban streets are all represented in the Lansing area. Testing was conducted for three consecutive weeks in November 1974, on Tuesday, Wednesday, and Thursday. Each subject was tested individually. The test took approximately fifteen to twenty minutes.

Those who were required to appear for reexamination did so by appointment. More time was given to these individuals to allow time for the perception test in addition to the regular procedures of the reexamination.

Test Equipment and Development Description

Equipment requirements demanded: (1) A 16mm cinemascope projector that could be stopped within two to three frames by the subject pressing a stop button on a hand-held control box. (2) A method of measuring and

recording the exact frames at which the film was stopped. (3) A method of recording the subject's audible comments.

A Singer-Graflex 16mm projector especially modified by the researcher to include an electrically attached stop button on a hand-held control box was used. In addition a portable wide-screen was constructed as no commercial screen was available.

Two systems were developed to measure at what point the subject stopped the film. The first method was by actually writing the frame numbers between each sprocket hole on the film. The second system was a special frame counter which was attached to the projector. This frame counter was reset for each subject at a predetermined point on the film.

A master control box was connected in such a manner that when the subject stopped the projector the attendant could deactivate the projector and at the same time activate a room light and tape recorder to record all audible comments.

Description of Test Procedures

The Driver Improvement Bureau provided a room in which the equipment could be set up to conduct the test. They also made appointments for those who were required to appear for reexamination.

The criteria for selecting license renewal applicants was a driving record free of violations and

accidents. When a subject met these initial requirements, he/she was directed to participate in the SDDHPT which replaced the normal renewal examination. As soon as a subject completed his/her test the next available applicant meeting the selection criteria was referred to the study examiner. This seemed to be the best substitute in that a totally random procedure could not be used. It was assumed that once the criteria were met the selection procedure did not relate to driving factors. Therefore, there were no factors related to the applicant's driving ability other than the criteria that affected the selection process. Those selected were asked to take the perception test in place of the renewal test.

The selected applicant was escorted to the testing room where he/she was asked to write his/her name, address, license number, and years of driving experience on a test answer sheet. Written instructions were given to him/her. He/she was seated in a chair near the projector facing the wide screen and given the control box. The subject was asked to listen to some instructions from a tape recorder. (These instructions were identical to the written instructions.) He/she was then told that his/her comments would be recorded.

After viewing sequence number 1, which was the sample, the subject was asked to listen to an explanation of that event on the tape recorder. Thereafter each time the subject stopped the projector the attendant recorded the frame number and continuous frame counter number. This procedure was done while the subject's comments were being recorded.

In addition to the comments described above, each subject was asked for his/her reaction to the test. These comments did not seem appropriate to the data and therefore were not included in the research. At the end of the test the subject was returned to the Driver License Bureau or Driver Improvement Bureau.

Two types of data were gathered from each subject: (1) verbal comments used to determine whether the subject identified the proper hazard, and (2) the frame number at which he/she stopped the projector which was used to evaluate whether or not he/she recognized the hazard in each sequence within the experts' limit. The tape comments of the examinees are discussed in Chapter IV.

The Null Hypotheses

The following is a restatement of the hypotheses of this study in the null form, i.e., stating that no significant relationships between the variables exist for the purposes of the statistical treatments.

$H_0 1$: When measured by recognition of the hazards as validated by traffic safety experts there will be no significant difference at the .05 level between the renewal and improvement groups.

$H_0 2$: When measured by recognition of the hazards within the limit set and validated by the traffic safety experts, there will be no significant difference at the .05 level between the renewal and improvement groups.

Analysis of Data

The data obtained were analyzed using a t-test of significance.

A t-test of significance was employed to determine the difference between the mean of the test scores on the SDDHPT when measured only by recognition of hazards of the individuals in the R Group and of individuals in the I Group. An .05 level of significance was used to determine the acceptance or rejection of the hypothesis $H_0 1$.

A t-test of significance was employed to determine the significance of the difference between the mean test score on the SDDHPT when measured by recognition of the hazard within the limit set and validated by the traffic safety experts of the individuals in the R Group and of individuals in the I Group. An .05 level of significance was used to determine the acceptance or rejection of the hypothesis $H_0 2$.

Other Questions Considered

In addition to the hypotheses tested it was considered of value to look at the relationships between the two groups Renewal and Improvement in each film sequence

and also compare the individual group means with the experts' frame number in the respective film sequences. Tables and figures were constructed to show these relationships and to assist in the clarification of their discussion. Finally a summary and discussion of the taped comments for each sequence was included with each table of the twelve sequences.

Summary

The Simulated Dynamic Driving Hazard Perception Test was developed from six driving simulation films provided by Allstate Insurance Company. Selection of sequences was based, when possible, on driving events included in the behavioral-environmental-traffic-situational-sequences as depicted and defined in the Michigan State University Driver Performance Measurement Research Project. Initially sixty-five sequences were cut and spliced. Two evaluations reduced this number to twenty-three. A pilot study was conducted and further reductions and adjustments were made. A group of experts representative of traffic safety disciplines recommended final adjustments confirming both the hazards and scoring system.

The sample consisted of two groups: (1) Drivers who had three negligent accidents within the past two years, and (2) drivers who had no accidents or violations on their driving record.

The subject while viewing the wide-screen motion picture test was required to press a stop button on a hand-held control box when in the subject's opinion a traffic hazard appeared in the film.

Two types of data were gathered from each subject: (1) His/her verbal comments, and (2) the frame number at which the subject stopped the projector. A t-test of significance was employed to determine the difference between the mean of the test scores of the two groups for both the recognition of the hazard as well as recognition of the hazard within the limit set by the experts. An .05 level was used to determine significance.

In Chapter IV the results of the analysis appear along with a summary of the subject's comments on the individual sequences as well as a look at the relationships within the individual sequences.

CHAPTER IV

ANALYSIS OF DATA

The results of the analysis of the data are presented in this chapter. These analyses include: (1) the difference between the mean of the two groups on the basis of recognition of hazards, and (2) the difference in the mean of the two groups on the basis of recognition of the hazards within the limit set by the traffic safety experts.

In addition other questions were considered such as individual sequence relationships between groups and comparisons of group means with the experts' frame number in all sequences.

Differences Between Group Means on Basis of Recognition Only

The following is a restatement of the null hypothesis:

$H_0 1$: When measured by recognition of the hazards as validated by traffic safety experts there will be no significant difference at the .05 level between Group R and Group I.

A t-test of significance was employed to determine the difference between the mean of the recognition scores

on the SDDHPT when measured by recognition of hazards of the individuals in the R Group and of individuals in the I Group. The mean of the recognition scores for the R Group was 7.31 sequences and for the I Group was 7.10 sequences.

The difference between the means was .21 with a confidence interval of ± 1.07. Since this confidence interval spans zero using a .05 level of significance, the null hypothesis was not rejected.

Because the null hypothesis was not rejected there is no indication of a statistically significant difference between the two sample groups in their ability to recognize the hazards in the SDDHPT.

Difference Between Group Means on Basis of Recognition and Time

The following is a restatement of the null hypothesis which was tested:

$H_0 2$: When measured by recognition of the hazards within the limit set and validated by the traffic safety experts, there will be no significant difference at the .05 level between Group R and Group I.

A t-test of significance was employed to determine the significance of the difference between the mean time limit scores on the SDDHPT when measured by recognition of the hazards within the limit set and validated by the traffic safety experts of individuals in the R and I Groups.

The mean of the time limit scores for the R Group was 2.79 sequences and for the I Group was 2.86 sequences.

The difference between the means was -.07 with a confidence interval of ± 1.04. Since this confidence interval spans zero using a .05 level of significance the null hypothesis was not rejected.

Since there was no statistical difference indicated between the R and I groups in the recognition of the driving hazards within the limit set by the traffic safety experts in the SDDHPT, the null hypothesis was not rejected.

Other Questions Considered

To portray group relationships within individual film sequences tables were constructed showing the following information: (1) the number of subjects who stopped the projector some time during the sequence and named the proper hazard, (2) the number of subjects who stopped the projector within the experts' frame number and indicated the proper hazard, (3) the mean film frame number and standard deviation for each of the above when applied to the subject within each group, and (4) the data necessary for determining the significance of the difference between the mean for the R Group and the mean for the I Group.

A separate figure shows relationships expressed in percent of the total number of subjects who stopped the projector some time during the sequence and named the proper hazard as well as the number of subjects who stopped

the projector within the experts' frame number and indicated the proper hazard.

A summary of the subjects' comments as well as a discussion of the data for each of the twelve sequences follows. Please note that no table or figure is included for the sample (Number 1) or for the control sequences 3 and 14 (which had no hazards).

Sequence 2

As the test car approaches a van parked at the curb on a residential city street, a person exits the van stepping into the path of the test car.

Table 1 shows that of the twenty-nine subjects in each group only one from the R Group and two from the I Group failed to recognize the hazard in sequence 2.

The mean frame number for stopping the projector and recognizing the hazard was 159.43 frames into the sequence for the R Group and 152.07 frames for the I Group, the difference being 7.36 frames. This mean difference of 7.36 frames was larger than the calculated confidence interval of 7.01 frames making a significant difference at the .05 level with respect to the film location at which they identified the hazard, thus the I Group did significantly better than the R Group.

Eight subjects in the R Group and twelve subjects within the I Group recognized the hazard at or before the

experts' frame number which was 152 for this sequence. The data show that the mean frame number for recognizing the proper hazard within the experts' limit was 147.63 frames for Group R and 146.33 frames for Group I, the difference being 1.30 frames. The calculated confidence interval was 5.88 frames which means that there was no significant difference between the two groups where identification of the hazard within the experts' limit was concerned.

Figure 1 depicts graphically the fact that most subjects in both groups were able to identify the hazard. The data show that 97 percent of the R Group and 93 percent of the I Group were successful.

Of interest, however, were the relatively few subjects from each group who were able to identify the hazard at or before the experts' frame number. Here the data shows that only eight subjects or 28 percent of the twenty-nine subjects in Group R and twelve or 41 percent of the subjects in Group I correctly identified the hazard at or before the established frame number.

The primary theme of the comments from both the R and I Group centered around the person exiting the van. The majority from each group saw and recognized this hazard; however, they did not see it and decide it was a hazard as soon as they should based on the experts' cut-off point. There was group consensus that action should have

been taken sooner. The question is: Could they have avoided the dangerous situation at the particular time that they stopped the projector? It is assumed that those who acted after the experts' limit (152) could not have safely avoided the hazard.

Table 1 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 2

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	28	159.43	9.99	27	152.07	15.20	7.36	$\pm$7.01*
Recognition of hazard Within experts' frame No. (Experts' frame No. = 152)	8	147.63	3.11	12	146.33	1.97	1.3	$\pm$5.88

Key:

Sequence 2	As the test car approaches a van parked at the curb on a residential city street, a person exits the van stepping into the path of the test car.
Group R	Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.
Group I	Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.
N_R, N_I	Represents number of subjects in respective Groups R and I
$\bar{X}_R$, $\bar{X}_I$	Represents mean frame number at which projector was stopped in respective Group R and I
SD_R, SD_I	Represents standard deviation in respective Groups R and I
CF	Represents confidence interval (Alpha equals .05)
*	Indicates significance.

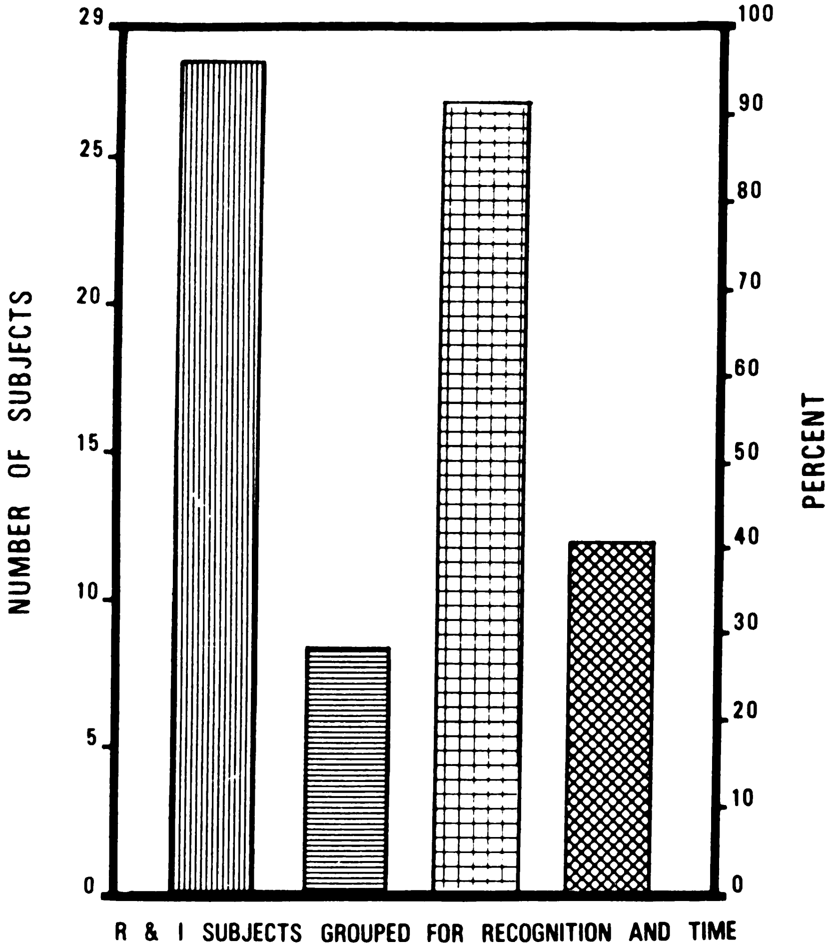
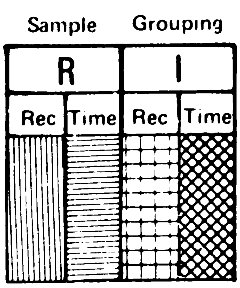


FIGURE 1

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 2

KEY

Sequence 2: As the test car approaches a van parked at the curb on a residential city street, a person exits the van stepping into the path of the test car.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 4

On a two-lane road in a rural area an oncoming car is being passed by another car forcing the test car off the road.

Table 2 shows that all twenty-nine subjects in each Group R and I recognized the hazard in Sequence 4.

The mean frame number for stopping the projector and recognizing the hazard was 91.79 frames into the sequence for the R Group and 91.28 frames for the I Group, the difference being .51 frames. This difference was less than the calculated confidence interval of 13.52 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Of the twelve subjects in the R Group and fourteen subjects within the I Group who recognized the hazard at or before the experts' frame number, which was 87 for this sequence, data show that the mean frame number for recognizing the hazard within the experts' limit was 69.75 frames for Group R and 68.86 frames for Group I, the difference being .89 frames. This difference was less than the calculated confidence interval of 10.58 frames which indicates no significant difference at the .05 level between the two groups within the experts' limit at which they identified the hazard.

Figure 2 depicts graphically the fact that all twenty-nine subjects in each group recognized the hazard. This is the only sequence in which 100 percent of the subjects did recognize the hazard, however, less than half of the subjects from each group were able to identify the hazard at or before the established frame number. Here the data show that twelve subjects or 41 percent of the twenty-nine subjects in Group R and fourteen or 48 percent of the subjects in Group I correctly identified the hazard at or before the established frame number.

There was a large difference in stopping points for the individuals within each group. Even though each person recognized the hazard, not all subjects recognized the hazard in sufficient time to avoid serious consequences.

Subjects who recognized the hazard within the agreed upon limit did so well below the required limit which indicates that they found it early, undoubtedly in time to take corrective action to avoid serious danger.

All subjects either stated or inferred that an oncoming car was in their lane as a result of performing a passing maneuver. Most of the subjects suggested at least one or all of the following alternatives as a driver: speed up, slow down and take the ditch to the right. Other frequent comments referred to an oncoming car passing on a curve with insufficient space for such a maneuver. The R

and I Groups were not notably different in their verbal reactions to this film clip.

Table 2 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 4

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	29	91.79	24.24	29	91.28	27.61	.61	± 13.52
Recognition of hazard Within experts' frame No. (Experts' frame No. = 87)	12	69.75	14.05	14	68.86	12.68	.89	± 10.58

Key:

Sequence 4 — On a two-lane road in a rural area, an oncoming car is being passed by another car forcing the test car off the road.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

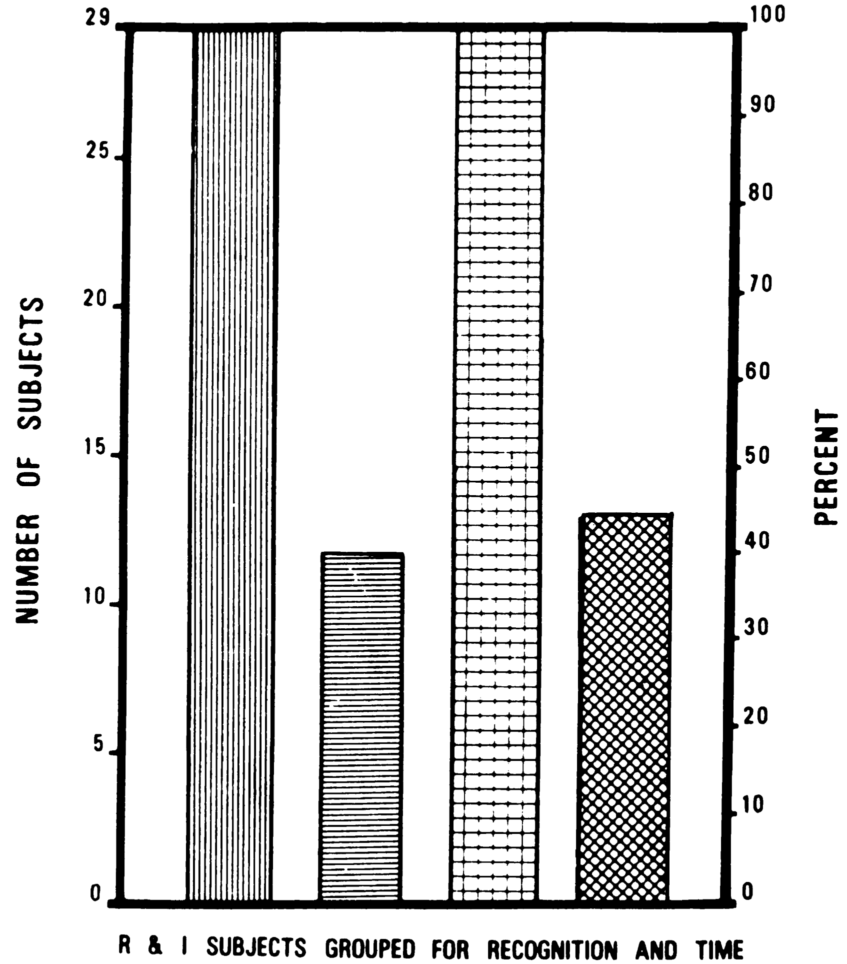
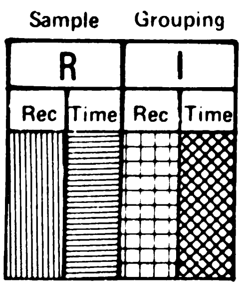


FIGURE 2

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 4

KEY

Sequence 4: On a two-lane road in a rural area, an oncoming car is being passed by another car forcing the test car off the road.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard

Sequence 5

A police car pursues another vehicle. Both cars pass the test car on a two-lane rural road.

Table 3 shows that of the twenty-nine subjects in each group, eighteen from the R Group and nineteen from the I Group recognized the proper hazard in sequence 5.

The mean frame number for stopping the projector and recognizing the hazard was 251.67 frames into the sequence for the R Group and 215.79 frames for the I Group, the difference being 35.88 frames. This difference was less than the calculated confidence interval of 53.56 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Eleven subjects in the R Group and fifteen from the I Group recognized the hazard at or before the experts' frame number which was 260 frames for this sequence. The data show that the mean frame number for the eleven recognizing the hazard within the experts' limit was 190 frames into the sequence for the R Group and 194.2 frames for the individuals in Group I, the difference being 4.20 frames. This difference was less than the calculated confidence interval of 43.15 frames which indicates no significant difference at the .05 level between the two groups within the experts' limit at which they identified the hazard.

Figure 3 depicts graphically the fact that more than half of the subjects in both groups were able to identify the hazard. The data show that eighteen subjects or 62 percent of the R Group and nineteen subjects or 66 percent of the I Group were successful.

Fewer subjects were able to identify the hazard at or before the established frame number. The data indicates that eleven subjects or 38 percent of the R Group and fifteen or 52 percent of the subjects in the I Group correctly identified the hazard at or before the established frame number.

There are two interesting developments that should be noted. The mean for Groups R and I were both better than the experts' limit and data indicate too many subjects stopped late into the sequence.

More subjects of the I Group specifically mentioned police or cop rather than emergency vehicle than those of the R Group. This might suggest that the I Group were more conditioned to look for the police rather than other types of emergency vehicles, or they interpret all flashing lights as being the police instead of different emergency vehicles. Many of the subjects in both groups failed to see the flashing light of the emergency vehicle in their rear view mirror. These people interpreted the problem to be the car that passed them in its effort to avert the police. This indeed was a hazard, but they

should have identified the flashing light of the police vehicle earlier and taken into account the problems which the pursuit was precipitating.

Table 3 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 5

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	18	251.67	97.04	19	215.79	62.22	35.88	± 53.56
Recognition of hazard Within experts' frame No. (Experts' frame No. - 260)	11	190.	56.04	15	194.2	48.59	-4.20	± 43.15

Key: Sequence 5 A police car pursues another vehicle. Both cars pass the test car on a two-lane rural road.

Group R Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I Represents standard deviation in respective Groups R and I

CF Represents confidence interval (Alpha equals .05)

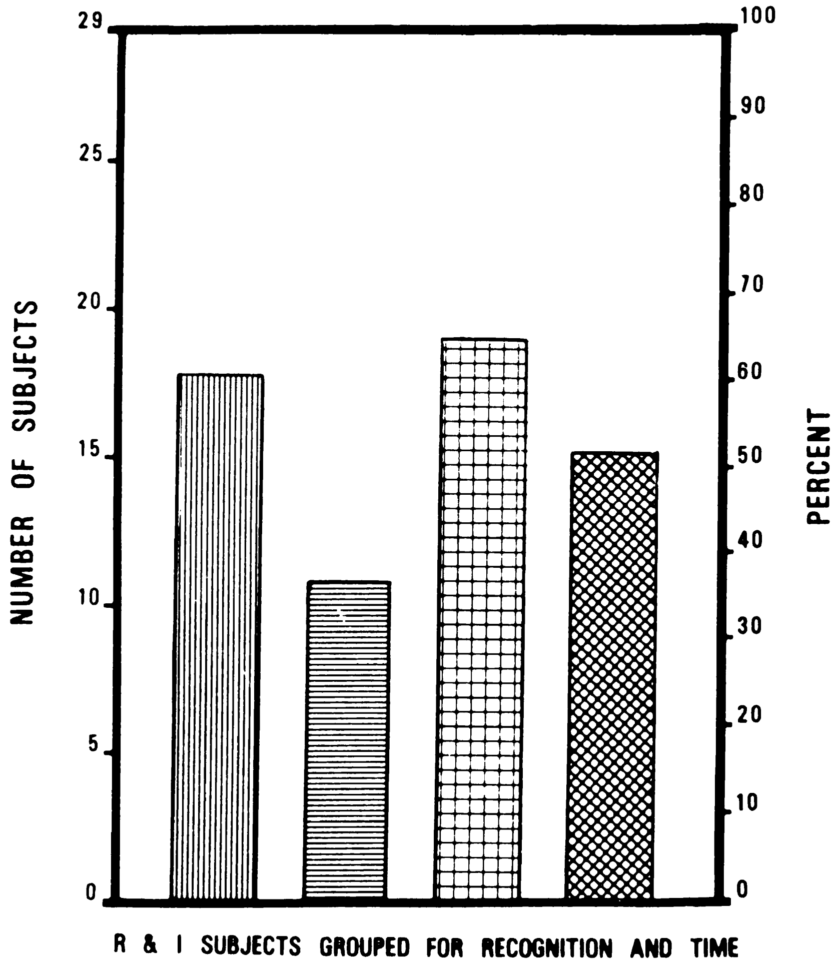
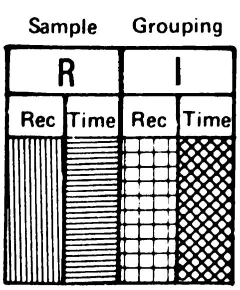


FIGURE 3.

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 5

KEY

Sequence 5: A police car pursues another vehicle. Both cars pass the test car on a two-lane rural road.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 6

A city street has two lanes in both directions. The test car is in the center lane approaching an intersection where an oncoming truck makes a left turn. A pedestrian appears from the left pushing a shopping cart in the crosswalk in front of the vehicle.

Table 4 shows that of twenty-nine subjects in each group R and I, five recognized the proper hazard in sequence 6.

The mean frame number for stopping the projector and recognizing the hazard was 96.4 frames into the sequence for the R Group and 111.6 frames for Group I, the difference being 15.2 frames. This difference was less than the calculated confidence interval of 67.83 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

One subject in each Group R and I recognized the hazard at or before the experts' frame number which was 75 for this sequence.

The frame number for recognizing the hazard within the experts' limit was 69 frames into the sequence for the subject in Group R and 60 frames for the subject in Group I.

Figure 4 depicts graphically the fact that few subjects in both groups were able to identify the hazard

of the truck making a left-hand turn in on-coming traffic. The data show that only five subjects or 17 percent in each group actually recognized the hazard.

Note that almost all subjects from each group were unable to identify the hazard at or before the established frame number. Here the data show only one subject or 3 percent from each group correctly identified the hazard at or before the established frame number.

Interestingly five subjects from each Group R and I recognized the hazard and commented about the truck making a left turn in front of the test car. The remaining comments in both groups almost exclusively named the pedestrian with a shopping cart near the end of the sequence as the hazard. To most subjects, however, the truck apparently did not appear to be close enough for the driver of the test car to take any action.

Table 4 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 6

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\overline{X}_R$	SD_R	N_I	$\overline{X}_I$	SD_I	$\overline{X}_R - \overline{X}_I$	CF
Recognition of hazard Anytime during sequence	5	96.4	22.67	5	111.6	61.62	- 15.2	±67.83
Recognition of hazard Within experts' frame No. (Experts' frame No. = 75)	1	69		1	60		9.	

Key: Sequence 6 A city street has two lanes in both directions. The test car is in the center lane approaching an intersection where an oncoming truck makes a left turn. A pedestrian appears from the left pushing a shopping cart in the crosswalk in front of the vehicle.

Group R Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I Represents number of subjects in respective Groups R and I

$\overline{X}_R$, $\overline{X}_I$ Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I Represents standard deviation in respective Groups R and I

CF Represents confidence interval (Alpha equals .05)

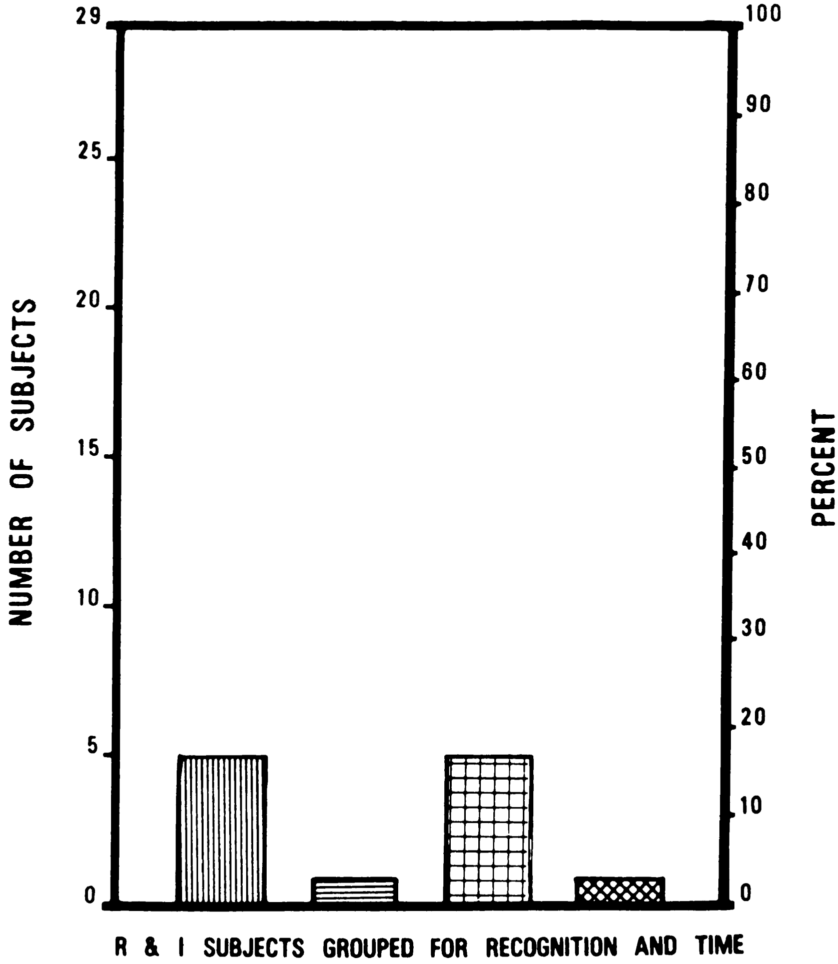
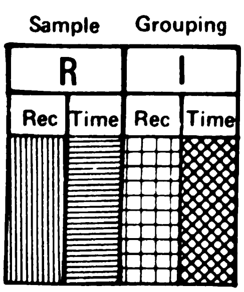


FIGURE 4

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 6

KEY

Sequence 6: A city street has two lanes in both directions. The test car is in the center lane approaching an intersection where an oncoming truck makes a left turn. A pedestrian appears from the left pushing a shopping cart in the crosswalk in front of the vehicle.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 7

On a busy city street a car is waiting to exit an alley near a traffic light as the test car approaches.

Of the twenty-nine subjects in each group, five from the R Group and seven from the I Group recognized the proper hazard in sequence 7 as shown in Table 5.

The mean frame number for stopping the projector and recognizing the hazard was 175.4 frames into the sequence for the R Group and 194 frames for the I Group, the difference being 18.6 frames. This difference was less than the calculated confidence interval of 30.79 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

One subject in each Group R and I recognized the hazard at or before the experts' frame number which was 157 for this sequence. The frame number for recognizing the hazard within the experts' limit was 140 frames into the sequence for the subject in Group R and 151 frames for the subject in Group I.

Figure 5 graphically displays the fact that few subjects in either Group R and I were able to identify the hazard by showing that five subjects or 17 percent of the R Group and seven subjects or 24 percent of the I Group were successful.

Once again note that most subjects from each group were unable to identify the hazard at or before the established frame number. The data show only one subject or 3 percent from each group correctly identifying the hazard at or before the established frame number.

While few subjects from each group did recognize the car in the alley to the right as the immediate problem, most subjects referred to the line of cars stopping ahead as the hazard.

Table 5 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 7

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	5	175.4	21.85	7	194	24.67	- 18.60	± 30.79
Recognition of hazard Within experts' frame No. (Experts' frame No. = 157)	1	140		1	151		- 11	

Key: Sequence 7 — On a busy city street a car is waiting to exit an alley near a traffic light as the test car approaches.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

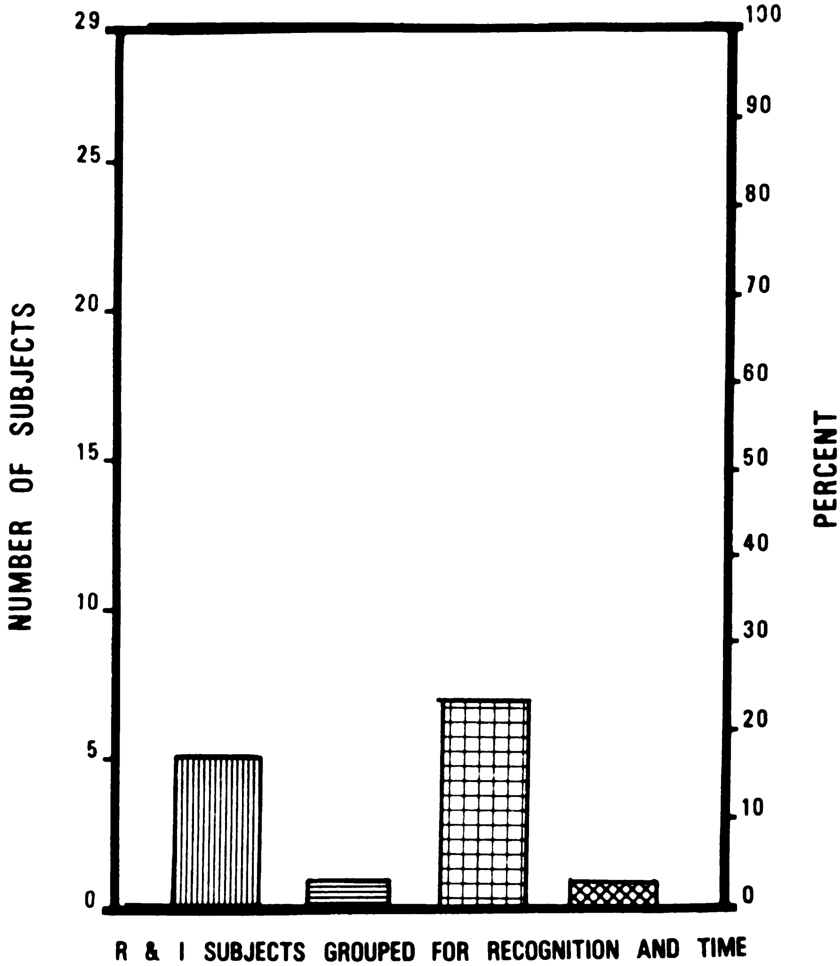
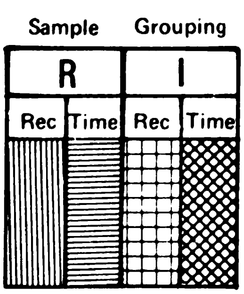


FIGURE 5

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 7

KEY

Sequence 7: On a busy city street a car is waiting to exit an alley near a traffic light as the test car approaches.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 8

The four-way flashers are operating on a double-parked car in a congested two-lane residential city street. When the test car nears the double-parked vehicle a child runs out from behind the vehicle across the path of the test car.

Of the twenty-nine subjects in each group sixteen from the R Group and thirteen from the I Group recognized the proper hazard in sequence 8 as shown in Table 6.

The mean frame number for stopping the projector and recognizing the hazard was 258.94 frames into the sequence for the R Group and 262.92 frames for the I Group, the difference being 3.98 frames. This difference was less than the calculated confidence interval of 67.52 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Thirteen subjects in the R Group and ten from the I Group recognized the hazard at or before the experts' frame number which is 317 frames for this sequence.

The data show that the mean frame number for recognizing the hazard within the experts' limit was 223.15 frames into the sequence for the R Group and 226.5 frames for Group I, the difference being 3.35 frames. This difference was less than the calculated confidence interval of 46.32 frames which indicates no significant difference

at the .05 level between the two groups in their ability to identify the hazard within the experts' limit.

Figure 6 depicts graphically that 55 percent of the R Group and 45 percent of the I Group were successful in identifying the hazard.

Approximately as many subjects were able to identify the hazard at or before the established frame number. The data show that thirteen subjects or 45 percent of the R Group and ten or 34 percent of those in Group I correctly identified the hazard at or before the experts' frame number.

It is interesting to note that both groups stopped well before the time limit, however, there was a great difference in the stopping points.

Comments from both groups were primarily concerned with two events, those who recognized the stopped vehicle and its flashing lights as a hazard and, second, those who considered the child darting across the road from the stopped car as the hazard. Several subjects volunteered advice as to what actions should be taken rather than naming the hazard itself.

Table 6 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 8

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\overline{X}_R$	SD_R	N_I	$\overline{X}_I$	SD_I	$\overline{X}_R - \overline{X}_I$	CF
Recognition of hazard Anytime during sequence	16	258.94	88.99	13	262.92	87.23	- 3.98	$\pm$67.52
Recognition of hazard Within experts' frame No. (Experts' frame No. = 317)	13	223.15	44.96	10	226.5	56.66	- 3.35	$\pm$46.32

Key:

Sequence 8 — The four-way flashers are operating on a double-parked car in a congested two-lane residential city street. When the test car nears the double-parked vehicle, a child runs out from behind the vehicle across the path of the test car.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\overline{X}_R$, $\overline{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

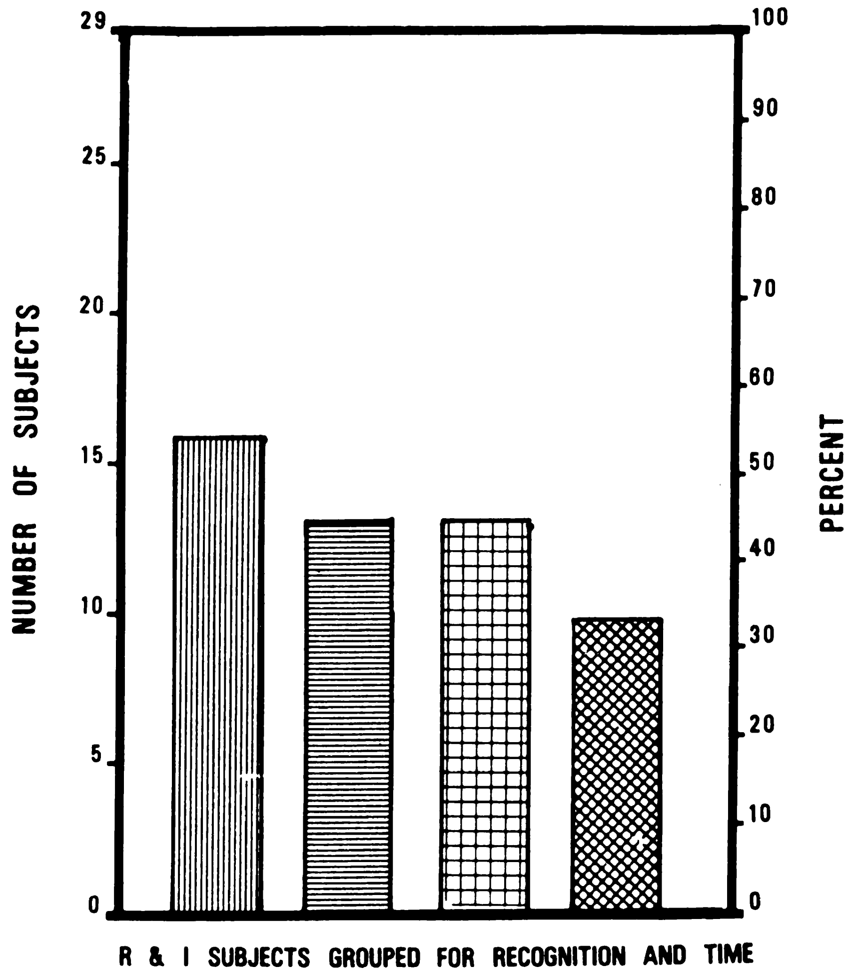


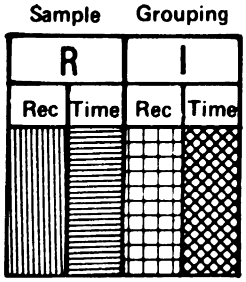
FIGURE 6

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 8

KEY

Sequence 8: The four-way flashers are operating on a double-parked car in a congested two-lane residential city street. When the test car nears the double-parked vehicle, a child runs out from behind the vehicle across the path of the test car.

Sample Grouping



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 9

A two-lane country road has an intersection designated in advance by a sign. A car is waiting to cross the intersection from the right. As the test vehicle approaches, a car from the left speeds through the intersection.

Table 7 shows that of the twenty-nine subjects in each group eleven from the R Group and five from the I Group recognized the proper hazard in sequence 9.

The mean frame number for stopping the projector and recognizing the hazard was 331.91 frames into the sequence for the R Group and 309.2 frames for the I Group, the difference being 22.71 frames. This difference was less than the calculated confidence interval of 77.25 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Four subjects in the R Group and five from the I Group recognized the hazard at or before the experts' frame number which was 337 frames for this sequence.

The data show that the mean frame number for recognizing the hazard within the experts' limit was 253.25 frames into the sequence for the R Group and 274 frames for Group I, the difference being 20.75 frames. This difference was less than the calculated confidence interval of 97.75 frames which indicates no significant difference

at the .05 level between the two groups identifying the hazard within the experts' limit.

Figure 7 shows that a limited number of subjects were able to identify the hazard. The data show thirty-eight percent of the R Group and 17 percent of the I Group were successful.

Few subjects were able to identify the hazard at or before the established frame number. The data show that only four subjects or 14 percent of the subjects in Group R and three or 10 percent of the subjects in Group I correctly identified the hazard at or before the established frame number.

The majority of the comments directed themselves to the car crossing the intersection from the left without making a stop. A few subjects referred to the car on the right waiting to cross the intersection. Some subjects did suggest that the intersection ahead was indicated by a sign along the road. Members of the R Group mentioned this part more than those of the I Group.

Table 7 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 9

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	11	331.91	69.75	5	309.2	59.28	+ 22.71	$\pm$77.25
Recognition of hazard Within experts' frame No. (Experts' frame No. = 337)	4	253.25	52.11	3	274	46.12	- 20.75	$\pm$97.75

Key: Sequence 9 — A two-lane country road has an intersection designated in advance by a sign. A car is waiting to cross the intersection from the right. As the test vehicle approaches, a car from the left speeds through the intersection.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

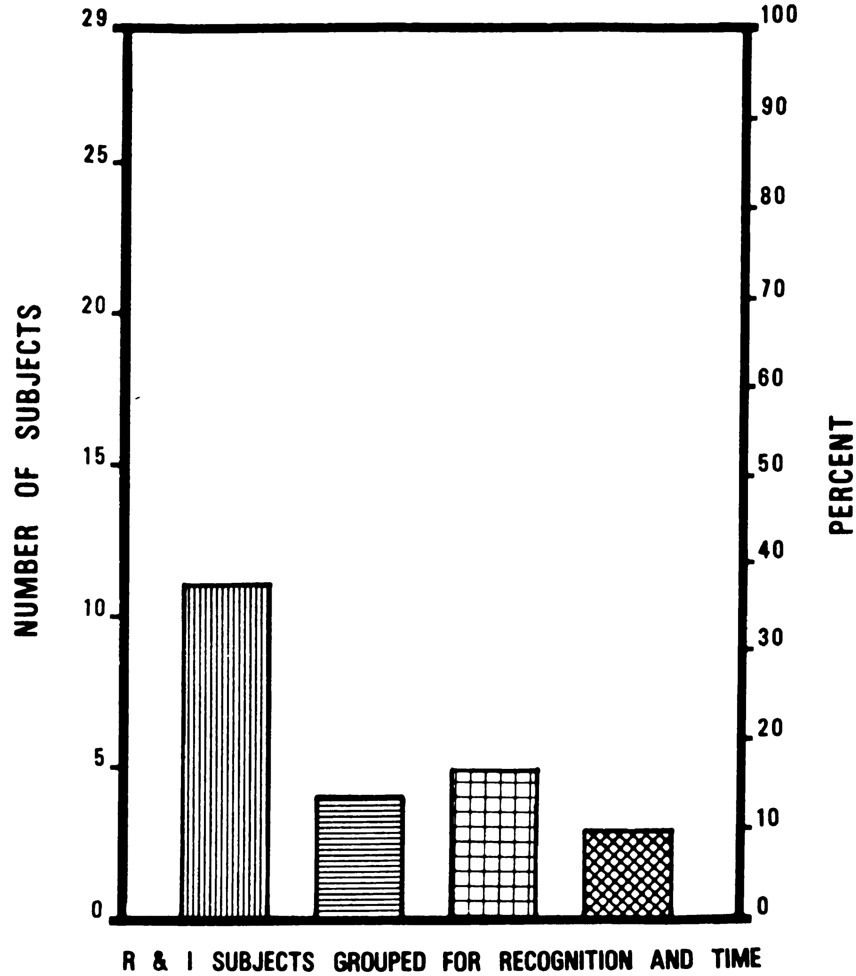
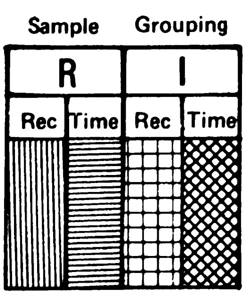


FIGURE 7

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 9

KEY Sequence 9: A two-lane country road has an intersection designated in advance by a sign. A car is waiting to cross the intersection from the right. As the test vehicle approaches, a car from the left speeds through the intersection.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 10

On a country road the test car approaches a disabled car barely off the road, its four-way flashers operating. A car is approaching in the opposite lane when suddenly children dash out from in front of the disabled vehicle.

Table 8 shows that of the twenty-nine subjects in each group nineteen from the R Group and twenty-one from the I Group recognized the proper hazard in sequence 10.

The mean frame number for stopping the projector and indicating recognition of the hazard was 211.05 frames into the sequence for the R Group and 228.81 frames for the I Group, the difference being 17.76 frames. This difference was less than the calculated confidence interval of 33.57 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Three subjects in the R Group and two from the I Group recognized the hazard at or before the experts' frame number which was 155 frames for this sequence.

The data show that the mean frame number for recognizing the hazard within the experts' limit was 111.0 frames into the sequence for the R Group and 107.5 frames for Group I, the difference being 3.5 frames. This difference was less than the calculated confidence interval

of 67.84 frames which indicates no significant difference at the .05 level between the two groups within the experts' limit and at which they identified the hazard.

Figure 8 portrays that the majority of subjects were able to identify the hazard. It indicates 66 percent of the R Group and 72 percent of the I Group were successful.

Few subjects from each group were able to identify the hazard at or before the experts' frame number. Figure 8 indicates that only three subjects or 10 percent of Group R and two or 7 percent of the subjects in Group I correctly identified the hazard at or before the experts' frame number.

A considerable number of subjects in the R and I Groups recognized the disabled car and commented about it. Some subjects referred to the car while others mentioned only the flashers. Many criticized its location without commenting that it might also be a hazard. The majority of subjects remarked about the oncoming vehicle and the children dashing into the roadway, however, many subjects recognized it too late and reserved their criticism for the children in the road.

Table 8   Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 10

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	19	211.05	54.6	21	228.81	51.84	- 17.76	± 33.57
Recognition of hazard Within experts' frame No. (Experts' frame No. = 155)	3	111.0	25.24	2	107.5	19.09	3.5	± 67.84

Key:

Sequence 10 — On a country road the test car approaches a disabled car barely off the road, its four-way flashers operating. A car is approaching in the opposite lane when suddenly children dash out from in front of the disabled vehicle.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

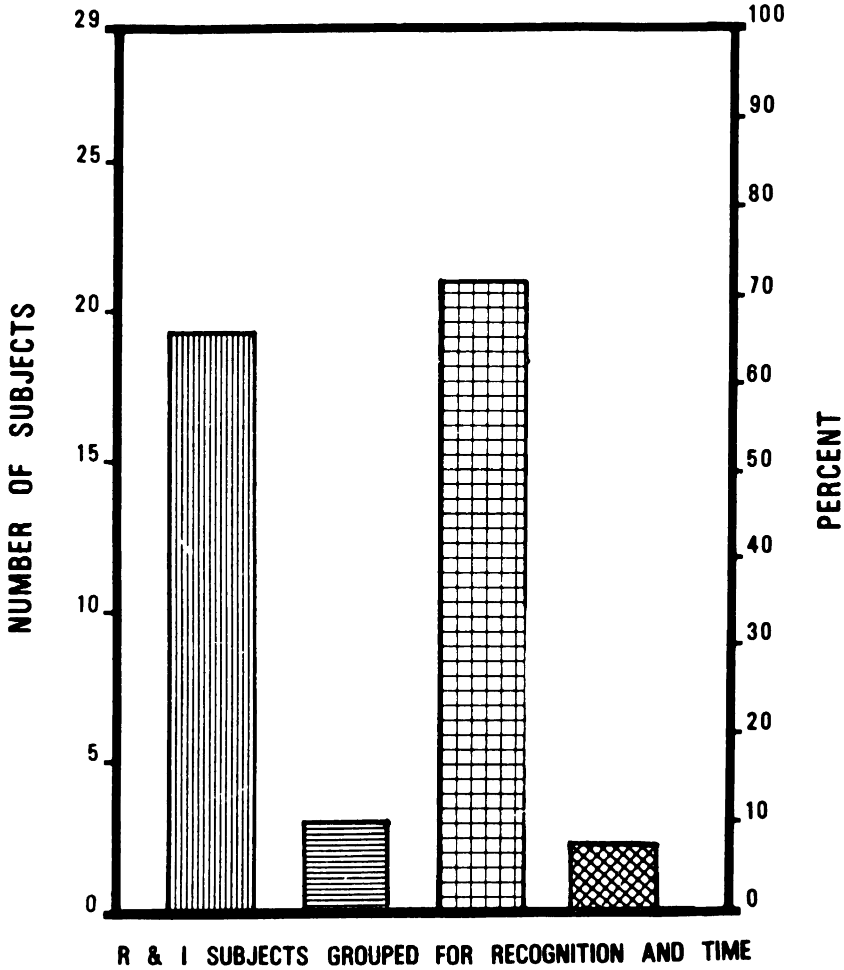
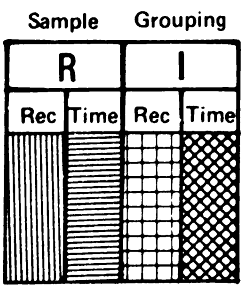


FIGURE 8

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 10

KEY Sequence 10: On a country road the test car approaches a disabled car barely off the road, its four-way flashers operating. A car is approaching in the opposite lane when suddenly children dash out from in front of the disabled vehicle.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 11

The test car drives up a snow-covered, slippery hill in a residential neighborhood. At the top of the hill a car partially obscured by high snow banks is backing from a driveway.

Table 9 shows that of the twenty-nine subjects in each group twenty-eight from the R Group and twenty-five from the I Group recognized the proper hazard in sequence 11.

The mean frame number for stopping the projector and recognizing the hazard was 175.39 frames into the sequence for the R Group and 188.36 frames for the I Group, the difference being 12.97 frames. This difference was less than the calculated confidence interval of 15.74 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Six subjects in the R Group and two from the I Group recognized the hazard at or before the experts' frame number which is 161 frames for this sequence.

The data show that the mean frame number for recognizing the hazard within the experts' limit was 132.67 frames into the sequence for the R Group and 159.0 frames for Group I, the difference being 26.33 frames. This difference was less than the calculated confidence interval of 74.84 frames which indicates no significant difference

at the .05 level between the two groups within the experts' limit at which they identified the hazard.

Figure 9 shows that most subjects in both groups were able to identify the hazard. Ninety-seven percent of the R Group and 86 percent of the I Group were successful.

Of interest, however, were the relatively few subjects from each group who were able to identify the hazard at or before the established frame number. Here the data show that only six subjects or 21 percent of the subjects in Group R and two or 7 percent of the subjects in Group I correctly identified the hazard at or before the established number.

All or most of the subjects, experts' limit notwithstanding, talked about or referred to the car backing out between the snow banks. Many mentioned the snow and slippery road conditions. One subject was concerned about the slippery hill before the backing car was even visible. Most of these comments relative to braking on ice came from the R Group.

Table 9 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 11

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\overline{X}_R$	SD_R	N_I	$\overline{X}_I$	SD_I	$\overline{X}_R - \overline{X}_I$	CF
Recognition of hazard Anytime during sequence	28	175.39	32.59	25	188.36	23.33	- 12.97	±15.74
Recognition of hazard Within experts' frame No. (Experts' frame No. = 161)	6	132.67	40.96	2	159.	2.83	- 26.33	±74.84

Key: Sequence 11 The test car drives up a snow-covered, slippery hill in a residential neighborhood. At the top of the hill a car partially obscured by high snow banks is backing from a driveway.

Group R Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I Represents number of subjects in respective Groups R and I

$\overline{X}_R$, $\overline{X}_I$ Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I Represents standard deviation in respective Groups R and I

CF Represents confidence interval (Alpha equals .05)

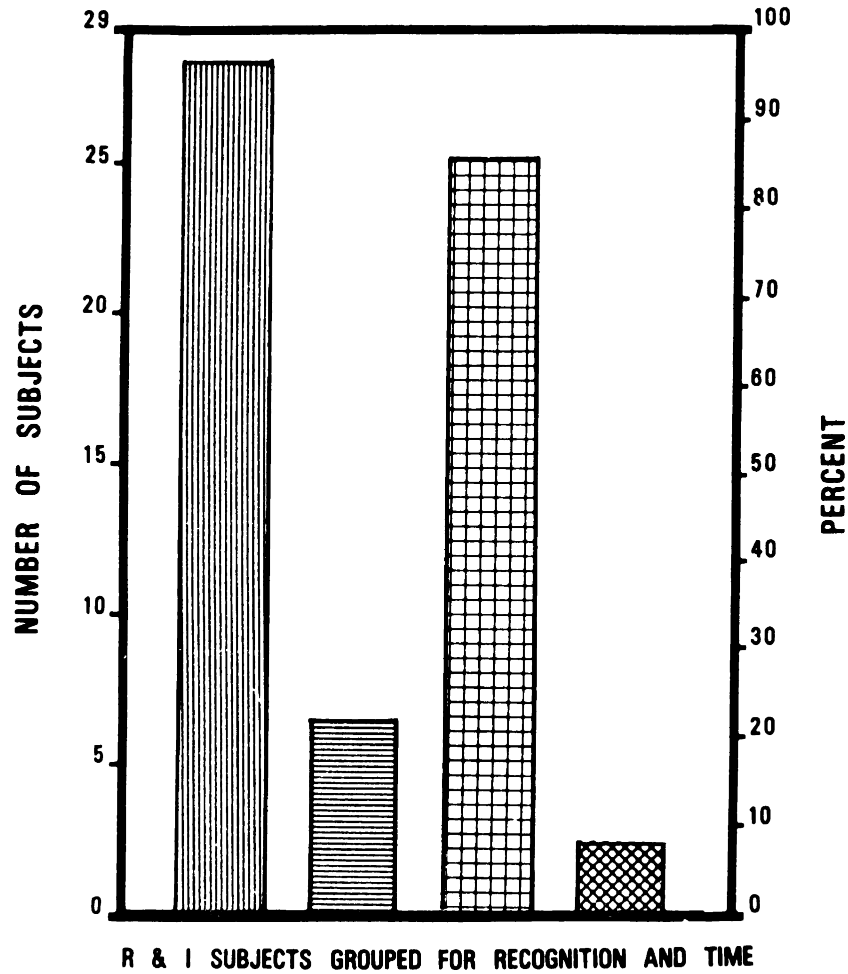
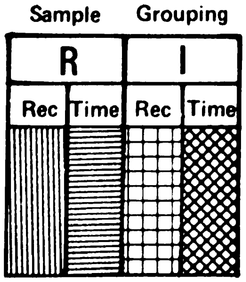


FIGURE 9

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 11

KEY Sequence 11: The test car drives up a snow-covered, slippery hill in a residential neighborhood. At the top of the hill a car partially obscured by high snow banks is backing from a driveway.

Sample Grouping



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 12

As the test car drives down a freeway during a rainstorm, another car attempting to merge comes carelessly close to the front of the test car.

Of the twenty-nine subjects in each group twenty-eight from the R Group and twenty-five from the I Group recognized the proper hazard in sequence 12 as shown in Table 10.

The mean frame number for stopping the projector and recognizing the hazard was 221.68 frames into the sequence for the R Group and 228.6 frames for the I Group, the difference being 6.92 frames. This difference was less than the calculated confidence interval of 24.5 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard.

Sixteen subjects in the R Group and twelve from the I Group recognized the hazard at or before the experts' frame number which is 240 frames for this sequence.

The data show that the mean frame number for recognizing the hazard within the experts' limit was 193.06 frames into the sequence for the R Group and 187.17 frames for Group I, the difference being 5.89 frames. This difference was less than the calculated confidence interval of 23.35 frames which indicates no significant difference

between the two groups in their ability at the .05 level to recognize the hazard.

Most subjects in both groups were able to identify the hazard as shown in Figure 10. Data indicate that 97 percent of the R Group and 86 percent of the I Group were successful.

Approximately one half of the subjects from each group were able to identify the hazard at or before the established frame number. Here the information reveals that sixteen subjects or 55 percent of Group R and twelve or 41 percent of the subjects in Group I correctly identified the hazard at or before the established frame number.

Most subjects in both groups referred to the car merging from the right. Many were eager to describe how to handle the situation. Some suggested increasing their speed while others would slow down. The lane on the freeway to the left of the test car was available. A large number suggested a lane change. About an equal number in both groups commented about the rain. Several subjects in the improvement group referred to the merging lane as a cross or side street.

It is interesting to note that the mean frame number for stopping the projector for both groups was below the experts' film frame number of 240.

Table 10 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 12

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	28	221.68	39.68	25	228.6	48.97	- 6.92	± 24.5
Recognition of hazard Within experts' frame No. (Experts' frame No. = 240)	16	193.06	26.21	12	187.17	33.82	5.89	± 23.35

Key: Sequence 12 — As the test car drives down a freeway during a rainstorm, another car attempting to merge comes carelessly close to the front of the test car.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

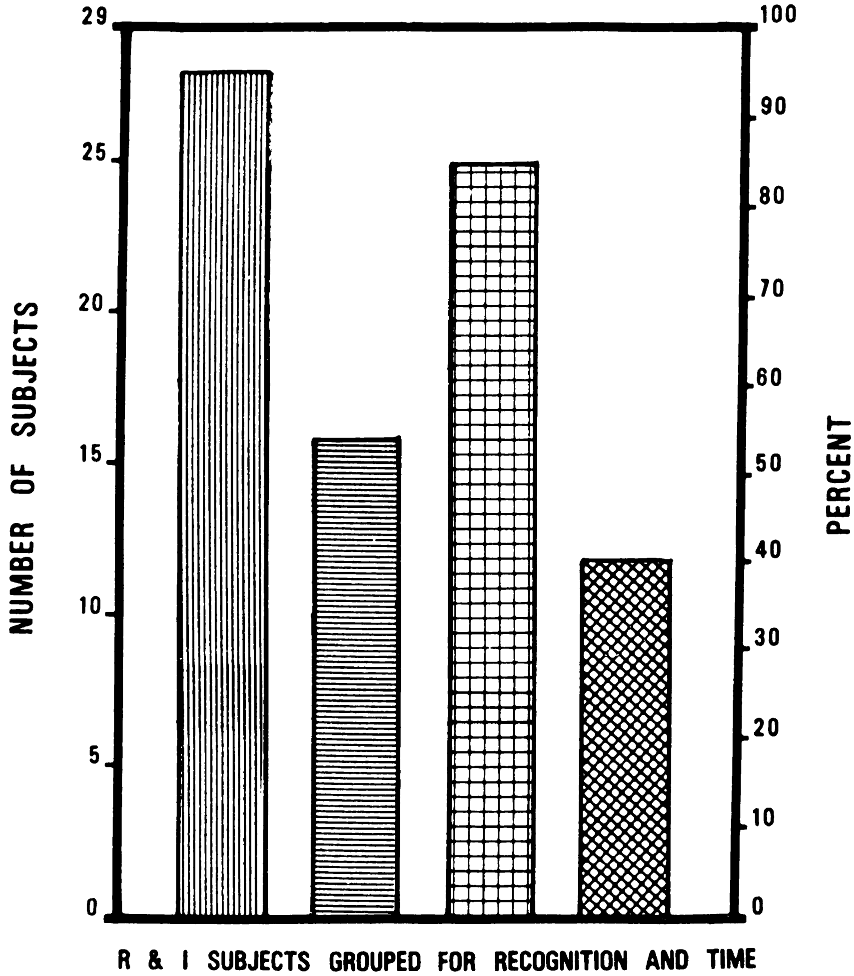
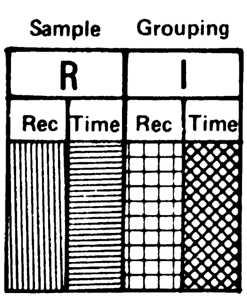


FIGURE 10

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 12

KEY

Sequence 12: As the test car drives down a freeway during a rainstorm, another car attempting to merge comes carelessly close to the front of the test car.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 13

The test car is in the center lane of a three-lane limited access highway with a car fast approaching from the rear.

In Table 11, of the twenty-nine subjects in each group thirteen from the R Group and sixteen from the I Group recognized the proper hazard in sequence 13.

The mean frame number for stopping the projector and recognizing the hazard was 290 frames into the sequence for the R Group and 228.24 frames for the I Group, a difference of 61.76 frames. This difference was less than the calculated confidence interval of 68.7 frames which indicates no significant difference at the .05 level with respect to the film location at which Groups R and I identified the hazard. In fact one subject of Group R and four subjects of Group I recognized the hazard at or before the experts' frame number which was 175 for this sequence. The one subject's frame number was 174 while the mean for the four individuals in Group I was 154.75 frames, the difference being 16.25 frames. This difference does not span the calculated confidence interval of 50.38 frames which indicates no significant difference in recognizing the hazard of the two groups within the experts' limit.

The data in Figure 11 shows the limited number of subjects in both groups who were able to identify

the hazard, 45 percent of the R Group and 55 percent of the I Group.

Very few subjects were able to identify the hazard at or before the established frame number. Considering this percentage wise, only 3 percent of the R Group and 14 percent of the I Group correctly identified the hazard at or before the established frame number of 175. More subjects from the I Group noticed and mentioned the car coming from the rear, however, more subjects in the R Group were concerned about normal freeway traffic flow.

Table 11 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 13

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\overline{X}_R$	SD_R	N_I	$\overline{X}_I$	SD_I	$\overline{X}_R - \overline{X}_I$	CF
Recognition of hazard Anytime during sequence	13	290.0	104.39	16	228.24	76.04	61.76	± 68.7
Recognition of hazard Within experts' frame No. (Experts' frame No. = 175)	1	171		4	154.75	14.17	16.25	± 50.38

Key: Sequence 13 — The test car is in the center lane of a three-lane limited access highway with a car fast approaching from the rear.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\overline{X}_R$, $\overline{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

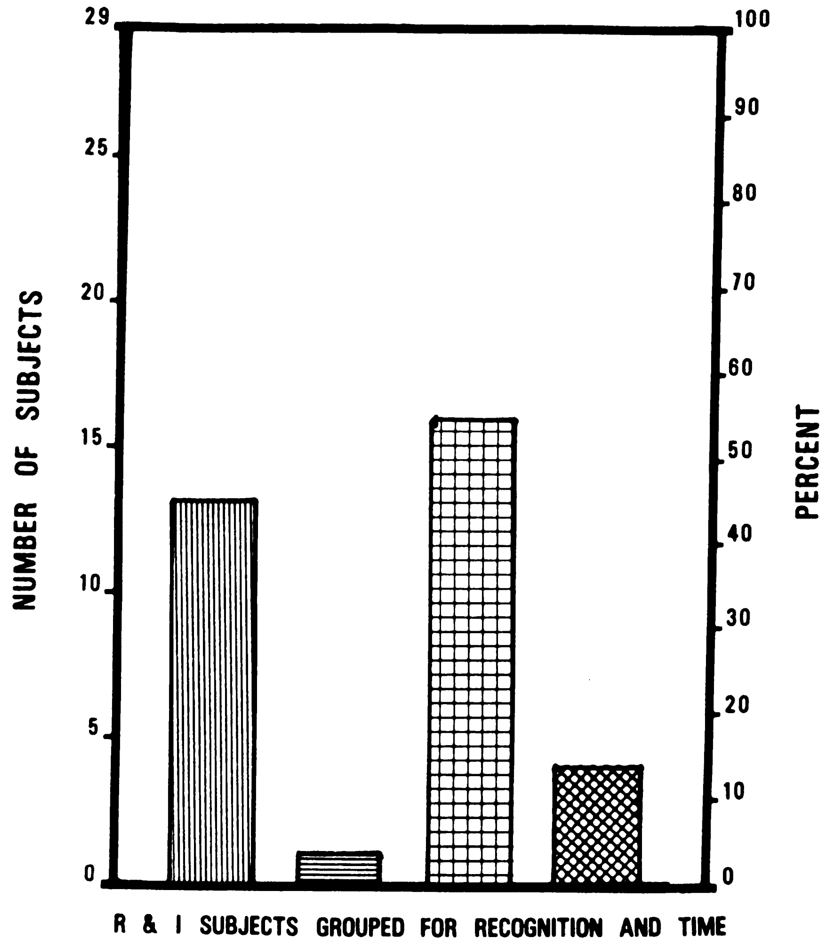
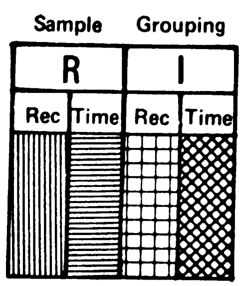


FIGURE 11

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 13

KEY

Sequence 13: The test car is in the center lane of a three-lane limited access highway with a car fast approaching from the rear.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Sequence 15

As the test car is traveling on a congested freeway, the car ahead reduces its speed, finally brakes, pulling off the freeway to a stop on the emergency strip.

In sequence 15, twelve of the twenty-nine subjects in Group R and thirteen in Group I recognized the proper hazard as shown in Table 12.

The mean frame number for stopping the projector and recognizing the hazard was 339.5 frames into the sequence for the R Group and 319.69 frames for the I Group, the difference being 19.81 frames. This difference was less than the calculated confidence interval of 48.96 frames which indicates no significant difference at the .05 level between groups in identifying the hazard.

Five subjects in the R Group and seven from the I Group recognized the hazard at or before the experts' frame number which is 335 frames for this sequence.

The data show that the mean frame number for recognizing the hazard within the experts' limit was 296.8 frames into the sequence for the R Group and 276.57 frames for Group I, the difference being 20.23 frames. This difference was less than the calculated confidence interval of 73.42 frames which indicates no significant difference at the .05 level between the two groups within the experts' limit at which they identified the hazard.

The R Groups' 339.5 mean film frame number is only 4.5 frames above the experts' film frame number while the I Groups' 319.95 is 15.31 frames less than the experts' film frame number (335).

More than half the subjects in both groups were unable to identify the hazard. The data in Figure 12 reveals that 41 percent of the R Group and 45 percent of the I Group accomplished the task.

In addition very few subjects from each group were able to identify the hazard at or before the established frame number. The data show that only five or 17 percent of the twenty-nine subjects in Group R and seven or 24 percent of the subjects in Group I correctly identified the hazard at or before the established frame number.

Many subjects in both groups recognized the vehicle ahead slowing, not considering it a hazard until the brake lights came on. However, they suggested cars approaching in adjacent lanes from the rear as hazards.

Table 12 Groups R and I driving hazard perception as measured by recognition and experts' frame number when applied to sequence 15

	Group R Total subjects = 29			Group I Total subjects = 29				
	N_R	$\bar{X}_R$	SD_R	N_I	$\bar{X}_I$	SD_I	$\bar{X}_R - \bar{X}_I$	CF
Recognition of hazard Anytime during sequence	12	339.5	42.02	13	319.69	71.22	19.81	±48.96
Recognition of hazard Within experts' frame No. (Experts' frame No. = 335)	5	296.8	21.37	7	276.57	70.47	20.23	±73.42

Key: Sequence 15 — As the test car is traveling on a congested freeway, the car ahead reduces its speed, finally brakes, pulling off the freeway to a stop on the emergency strip.

Group R — Consists of twenty-nine license renewal applicants with a driving record free of violations and accidents.

Group I — Consists of twenty-nine drivers with three negligent accidents within the past two years who were required to appear for reexamination at the Driver Improvement Bureau.

N_R, N_I — Represents number of subjects in respective Groups R and I

$\bar{X}_R$, $\bar{X}_I$ — Represents mean frame number at which projector was stopped in respective Groups R and I

SD_R, SD_I — Represents standard deviation in respective Groups R and I

CF — Represents confidence interval (Alpha equals .05)

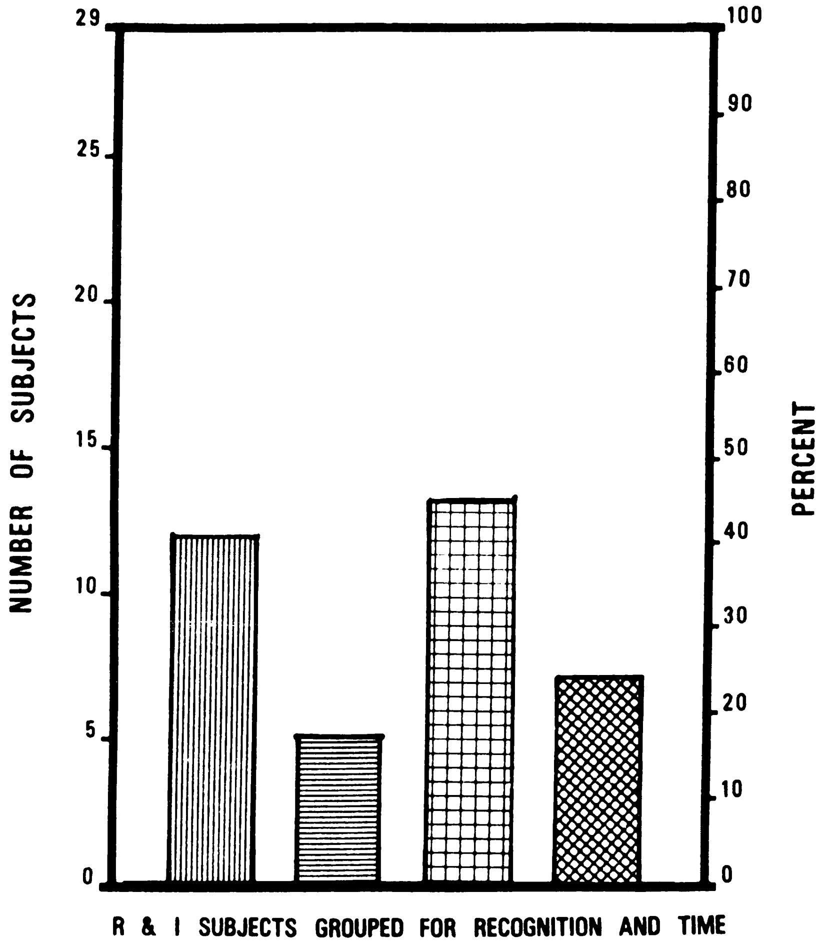
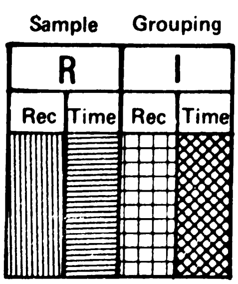


FIGURE 12

HAZARD RECOGNITION OF SUBJECTS IN SEQUENCE 15

KEY

Sequence 15: As the test car is traveling on a congested freeway, the car ahead reduces its speed, finally brakes, pulling off the freeway to a stop on the emergency strip.



R: Consists of 29 drivers license renewal applicants who had no accidents or violations on their driving records.

I: Consists of 29 drivers who were required to appear at the Driver Improvement Bureau for reexamination because of three negligent accidents within the past two years.

Rec: Number of subjects also expressed in percent who stopped projector before end of sequence and named proper hazard.

Time: Number of subjects also expressed in percent who stopped projector within experts' limit and indicated the proper hazard.

Summary

The results of the analysis of the data reveal: (1) when measured only by recognition of hazards a t-test of significance indicated no significant difference at the .05 level between the mean score of the R and I groups; (2) when measured by recognition of the hazards within the time set and validated by traffic safety experts a t-test of significance indicated no significant difference at the .05 level between the mean scores of the R and I groups.

To show relationships within each of the individual film sequences, a table was constructed showing (1) the number of subjects who stopped the projector some time during the sequence and named the proper hazard; (2) the number of subjects who stopped the projector within the experts' limit and indicated the proper hazard; (3) the mean film frame number and standard deviation for each of the above applied to the respective groups, and (4) data to determine the significance of the mean difference between the R and I Groups. Also subjects recognizing the hazard as well as those recognizing the hazard within the set limits were expressed numerically as well as in percent and displayed in graphical form.

A summary of the subjects' comments as well as a discussion of the data preceded each table.

CHAPTER V

SUMMARY, MAJOR FINDINGS, CONCLUSIONS, RECOMMENDATIONS, AND DISCUSSIONS

Summary

The primary purpose of this thesis was to develop an instrument to measure a phase of that process called dynamic driver perception, primarily that of driving hazard recognition. A secondary purpose was to determine how drivers respond to the instrument.

To accomplish these purposes two tasks were undertaken: (1) a motion picture film sequence instrument was developed to be used as a test in evaluating the ability of drivers to recognize driving hazards, and (2) a means to evaluate the manner in which drivers responded to the instrument was accomplished.

The instrument consisted of fifteen, 16mm film clips or sequences depicting various types of driving hazards called the Simulated Dynamic Driving Hazard Perception Test (SDDHPT).

The SDDHPT was developed from six driving simulation films provided by Allstate Insurance Company. Selection of sequences was based, when possible, on driving

events included in the behavioral-environmental-traffic-situational-sequences as depicted and defined in the Michigan State University Driver Performance Measurement Research Project. Sixty-five sequences were cut and spliced. Two evaluations reduced this number to twenty-three. A pilot study was conducted after which further modifications were made. A group of experts representative of traffic safety disciplines recommended final adjustments confirming both the hazards and grading systems.

The sample consisted of two groups: (1) Drivers who had three negligent accidents within the past two years and (2) Drivers who had no accidents or violations on their driving record.

Subjects viewed the wide-screen motion picture test on an individual basis and were required to press a stop button on a hand-held control box when in the subject's opinion a traffic hazard appeared in the film. Two types of data were gathered from each subject: his/her verbal comments and the numerical scores for each sequence.

A t-test of significance was employed to determine the difference between the mean of the test scores of the two groups for both the recognition of the hazard and recognition of the hazard within the limit set by the experts. An .05 confidence level was used to determine significance.

To see relationships within each of the individual film sequences, a table was constructed showing (1) the number of subjects who stopped the projector some time during the sequence and named the proper hazard; (2) the number of subjects who stopped the projector within the experts' limit and indicated the proper hazard; (3) the mean film frame number and standard deviation for each of the above applied to the respective groups, and (4) data to determine the significance of the mean difference between the R and I Groups. Also subjects recognizing the hazard as well as those recognizing the hazard within the set limits were expressed numerically, in percentage, and displayed in graphical form.

Major Findings

The following is a restatement of the null hypotheses which were tested:

$H_0 1$: When measured by recognition of the hazards as validated by traffic safety experts there will be no significant difference at the .05 level between the renewal and improvement groups.

$H_0 2$: When measured by recognition of the hazards within the limit set and validated by the traffic safety experts, there will be no significant difference at the .05 level between the renewal and improvement groups.

The results of the analysis of the data revealed:

1. When measured only by recognition of hazards, a t-test of significance indicated no significant difference at the .05 level between the mean score of the R and I Groups.

2. When measured by recognition of the hazards within the time set and validated by traffic safety experts, a t-test of significance indicated no significant difference at the .05 level between the mean scores of the R and I Groups.

3. Findings from each sequence indicate that except for sequence two there was no significant difference with respect to the film location at which the two groups identified the hazard.

4. With respect to the identification of the hazard within the experts' limit there was no significant difference between groups in all sequences.

5. The majority of subjects in Groups R and I were unable to identify the hazards confirmed by the experts in six of twelve sequences.

6. Data show that many subjects recognized the correct hazards, but few recognized the hazards within the experts' limit.

Conclusions

1. The SDDHPT did not distinguish between the R and I Groups for either the identification of hazards or the recognition of hazards within the experts' limit.

2. Often hazards were recognized too late to take corrective action.

3. The great variation in test scores in relation to time indicate that some drivers have acquired well-developed perceptual skills while other drivers lack such skills.

4. The SDDHPT did produce a variation in scores which indicates it did distinguish among drivers which could be due to chance.

5. The groups tested may not have been different as drivers in their hazard perception abilities.

6. An accident and violation-free driving record does not guarantee that an individual will recognize driving hazards when applied to this study.

7. A standard other than violations and accident involvement for grouping subjects might produce different results.

8. Drivers are not using systematized search procedures.

9. In general, drivers wait too long to make decisions.

Recommendations

1. A study should be undertaken to determine if persons identified as problem drivers differ in visual perception capability from recognized safe commercial drivers as measured by the SDDHPT.

2. Research should be undertaken in which a correlation of the SDDHPT with another measure of visual perceptual capabilities is made.

3. A replication of this investigation using another visual perceptual measure should be done.

4. Research should be instituted in which a correlation of the SDDHPT with the Michigan State University Driver Performance Measurement instrument should be evaluated.

5. A correlation of the SDDHPT with the Project METER (Machine, Examination, Teaching, Evaluation and Reeducation) should be conducted.

6. To establish norms applicable to the general population, large groups of matched subjects should be tested by the SDDHPT.

Discussion

The SDDHPT did not distinguish between the R and I Groups in terms of recognition of hazards nor recognition of these hazards within the experts' limit when compared by t-tests of the means. However, it did produce a variation in raw scores which indicate that it did distinguish among drivers. The problem is, are the two groups that were tested different as drivers or not? If the Michigan State University Driver Performance Measurement instrument had been used on the same subjects, would those doing well on it also do well on the SDDHPT and vice versa?

Even though a person's record shows no violations or accidents, it does not necessarily guarantee that that individual is a good or poor driver. A standard other than violation and accident involvement is necessary to evaluate drivers. Perhaps the SDDHPT does distinguish between good and poor drivers if in fact a reliable standard is used to make that decision. However, its intent was to measure only driving hazard recognition and one's ability to recognize such hazards early.

The experts agreed upon the hazard and the recognition time necessary in each film sequence. The test then administered showed a variation of scores which indicated that some drivers respond before others.

The mean of the time limit scores for both the R and I Groups were extremely low, 2.79 and 2.86 sequences respectively. Why did so many subjects have so much trouble recognizing the hazard within the experts' limit? Maybe the drivers were poor or the experts were too idealistic in what they thought drivers could or should see and respond to in a dynamic situation. The key to the traffic safety problem could very well be locked up in such a discrepancy between the idealistic represented by the experts and reality represented by the subjects tested. Further research with the SDDHPT using a large sample should prove helpful.

Each of the studies, Adams, Weinstein, Spicer, the METER Project, and this study differ in how they attempt to measure driver perception. The test used in this research falls somewhere between that which Spicer did and the elaborate computerized system of the METER Project. However, if it can do the job of measuring the driver's ability in hazard recognition, why have the costly equipment? Neither Adams or Weinstein used motion pictures which in this author's opinion was an omission.

In Project METER a motion picture was used in place of the driver's road test in a license examination. This caused the researchers to discard the simulation film and produce their own so as to be able to carry the subject further into hazardous situations. Whereas in the SDDHPT the experts desired early recognition which did not call for the hazard to go beyond that which the simulation film accomplished.

An extensive amount of research has been completed pertaining to the driver and driving task. A few examples have been cited. This study dealt with one aspect of more extensive research, primarily that of testing driver hazard recognition by the use of the SDDHPT. It would seem that the above test with certain refinements could be used on a group of drivers who were tested with the Michigan State University Driver Performance Measurement Instrument. If

there was high correlation between the two tests, then the SDDHPT could be used on a large scale at reasonable expense.

Nearly all evaluation of drivers has been on the basis of accident or traffic violation involvement rather than on performance based on safe driving habits and procedures.

It is very likely that a sizeable number of drivers who are never involved in an accident or cited for a violation of the law are in reality very poor drivers. This may be one additional factor involved in the changing accident population.

Part of the rationale in this study was the assumption that the Allstate Simulation Films would be more real than any other known, practical simulation system. Subjects reacted to a color motion picture projected on a wide screen which duplicated the real life driving environment. This is in great contrast to investigations like Weinstein and Adams in which still pictures were used of near notebook size.

One of the most valuable uses of the SDDHPT may well be as a teaching tool for driver education teachers to help students in their early recognition of hazards in various driving situations.

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APPENDICES

APPENDIX A

PARTICIPANT INSTRUCTIONS AND OBJECTIVES FOR THE SIMULATED DYNAMIC DRIVING HAZARD PERCEPTION TEST

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PARTICIPANT INSTRUCTIONS AND OBJECTIVES FOR THE SIMULATED DYNAMIC DRIVING HAZARD PERCEPTION TEST

INSTRUCTIONS

You are about to take part in an experimental study, the results of which may someday play a small part in improving traffic safety. When viewing the film, assume you are behind the wheel of the car from which the picture was taken. The film will be made up of a variety of driving situations lasting from only a few seconds to as long as half a minute. In each situation you are to assume you are the driver. If any hazardous or potentially hazardous situation develops that, in your opinion, requires you to take some action as a driver, such as decelerate, brake, accelerate, steer left, steer right, et cetera, you are to immediately stop the projector and tell the attendant what hazardous or potentially hazardous situation caused you to act. The attendant will tell you when it is all right to start the projector again to see the remainder of that sequence. Not all of the situations require action and in other situations action on the part of the driver may be

questionable. Be sure to push the stop button as soon as possible, but not before you can name the hazard.

The first sequence you will see is a sample so that you might gain a full understanding of how the sequences work. After viewing No. 1, you will hear on the tape an explanation of when and why you should have reacted. Please treat the sample as a regular sequence.

PARTICIPANT OBJECTIVES

As a participant of this study I will:

1. Identify hazardous or potentially hazardous situations when viewing the film.

2. Stop the projector when I would normally take some action as a driver such as decelerate, brake, accelerate, steer left, steer right, etc.

3. Name hazard or hazards to attendant.

4. Wait for OK from attendant to continue viewing film.

APPENDIX B

SCORE SHEET FOR THE SIMULATED DYNAMIC DRIVING HAZARD PERCEPTION TEST

APPENDIX B

Name ____________________

Address ____________________

Years as Licensed Driver ______

Driver License No. __________

Date ____________________

Score Sheet

Simulated Dynamic Driving Hazard Perception Test conducted under the auspices of the Highway Traffic Safety Center, Michigan State University, East Lansing, Michigan.

Sequence	Film Frame	Counter Number
1.	____	____
2.	____	____
3.	____	____
4.	____	____
5.	____	____
6.	____	____
7.	____	____
8.	____	____
9.	____	____
10.	____	____
11.	____	____
12.	____	____
13.	____	____
14.	____	____
15.	____	____